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THE ROYAL ENGINEERS JOURNAL.

Vol. II. No. 1. JULY, 1905.

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LANDING OPERATIONS AT THE ESSEX MANŒUVRES, 1904.

TYPE OF LANDING STAGE, LITTLE HOLLAND.

LANDING FROM PINNACES, CLACTON.

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*NEW MEASUREMENTS OF THE DISTANCE OF THE SUN.**

By A. R. HINKS, M.A.

WHEN I received the honour of an invitation to lecture at the School of Military Engineering on some astronomical subject, I had little difficulty in making my choice of a topic. There is just one subject on which I may speak with some little first-hand knowledge; and by great good fortune that subject is concerned with a problem which has both in its nature and its history a connection with the Corps of Royal Engineers.

The problem of the determination of the distance of the Sun is, in some respects at least, the most fundamental in the whole range of astronomy, for the number which represents it is involved in almost any calculation of distances and masses, of sizes and densities, either of planets or their satellites or of the stars. The distance of the Sun bears somewhat the same relation to other problems of celestial surveying as the size and shape of the earth bear to terrestrial. It may not always appear on the surface, but it is generally concealed somewhere in the depths of the calculations. And I am compelled to confess that in one respect the earth-measurers have the advantage over astronomers. The utmost that the astronomer can do is to show that the distance of the Sun is so many times the radius of the earth. But ask him to put it into miles and he is powerless to do so until the geodesists have told him how large the earth is; and it is there that, in the very nature of the case, we are compelled to depend in the end upon the scientific labours of your Corps.

Distance of Sun corresponding to Different Values of the Solar Parallax and Clarke's Figure of 1880.

π.	Miles.	Kilomètres.
8″·760	93,321,000	150,180,000
8″·770	214,000	150,010,000
8″·780	108,000	149,840,000
8″·790	002,000	670,000
8″·800	92,896,000	500,000
8″·810	791,000	330,000
8″·820	686,000	149,160,000
8″·830	581,000	148,990,000
8″·840	476,000	820,000

A difference of 0″·01 in the parallax is equivalent to 106,000 miles or 170,000 kilom.

* Lecture delivered at the Royal Engineers Institute on 9th February, 1905.

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Let us look at the matter for a moment as a problem in pure surveying. To measure the distance of the Sun we have as a base a chord somewhat less than the diameter of the Earth, since observations cannot be made on a heavenly body when it is actually on the horizon. Suppose we put our base line at $\frac{9}{10}$ of the diameter. Our problem is to determine the distance of a body so far away that the whole diameter of the Earth subtends at it an angle of only about 17·6 seconds of arc; and with our somewhat diminished base this angle is reduced to a little less than 15″. I believe that the length of your base upon the Great Lines of Chatham is about 1,730 ft. Imagine that from that base you had to determine with an accuracy greater than one in a thousand the distance of an intersected point about 4,500 miles away, as far away as Chicago; and you have a problem which is by comparison simplicity itself. For the ends of our 7,000-mile base are not visible from each other, being on opposite sides of the world; and our angles at the base must be determined by a complicated reference to the zenith, with all the well-known impossibilities of determining absolute places in the sky increased by the special difficulties that arise when the object to be observed is the Sun. You will readily grant that to determine the distance of the Sun by direct observation of that body is impossible, unless you are content with an accuracy of about 1 in 10.

Now it is a curious fact that there is a way of obtaining the distance of the Sun with an accuracy of ten per cent. with no other instrument than a clock keeping accurate time; you do it by observing the times of minima of the variable star Algol. Every 2 days 21 hours Algol drops more than a magnitude, and does this with a regularity which would be unfailing were it not for the fact that at one season of the year we are nearer the star by nearly the whole diameter of the Earth's orbit than we are at the opposite season; and light takes about 16 minutes to traverse that distance. In the middle of November the eclipses of Algol are taking place 8 minutes earlier than the average; in May, could we observe the star so near the Sun, they would be found 8 minutes behind their time; and a practised observer could, on a long series of observations, determine that inequality, with a total range of 16 minutes, well within 2 minutes, that is to say, with an accuracy of about 10 per cent. We have then only to combine this quantity with the known velocity of light, and we have a measure of the Sun's distance. A mere curiosity in itself, it will serve to introduce us to some indirect ways of determining the distance of the Sun which have, both practically and historically, a peculiar interest and importance.

At the present time we are in the thick of a new determination of the distance of the Sun, on a scale of operations greater than has been known before. More than 50 observatories of the Northern hemisphere are engaged more or less deeply on the work, which has

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occupied a great many of us closely for the last four years, and will give plenty of trouble to some of us for several years to come. Before we enter upon the consideration of the new method and the new opportunities, we might well pause to answer the question, which is by no means superfluous,—How does it come about that, at the end of the 19th century, which had seen attempts almost innumerable to measure the distance of the Sun, the result was still so much in doubt that it was worth while to concentrate quite a large proportion of the total astronomical energy of the world upon a new attempt? I believe that we shall find some explanation of this fact if we examine the history of the various values of the Solar Parallax that were used in the *Nautical Almanac* during the 19th century.

A determination of the distance of the Sun by direct observation of the Sun itself is impracticable; the Sun is too difficult an object to observe with any great accuracy; its distance is too great, and our base is too small, for any method of direct trigonometrical survey to be possible. But we can in effect diminish its distance by substituting for it one of the planets, which can be more accurately observed; for when the distance of any one planet from the Earth is known, the dimensions of other orbits follow by the application of Kepler's 3rd law. And at the same time we can, as we shall see, secure the inestimable advantage that the measures to be made are relative and not absolute.

Let me digress for a moment to insist upon the importance of this distinction. If you wished to find the difference in latitude and longitude between your Institute and the trigonometrical point at Darland, you might determine the latitude and longitude of each, and take the differences; or you might triangulate from one to the other. One is an absolute method, the other a relative; and it is scarcely necessary to emphasize the difference in accuracy between the two. We shall see that, various as are the kinds of measurement which may be made to contribute to a knowledge of the Solar parallax, they are all of them relative measurements. For example, one may observe the displacement of the planet Mars among the stars, as seen from a northern and a southern station, say Greenwich and the Cape; or one may observe the displacement of the place of Venus in transit across the Sun from stations suitably chosen. In each case we are measuring the displacement as viewed from different stations of a near object with respect to one further off, the displacement of Mars among the stars or of Venus against the Sun. We have secured the advantages that the parallactic displacement to be measured is greater than that of the Sun itself; that the objects to be observed, Mars or Venus, are better adapted for observation; and that the measures are relative.

In the middle of the 18th century Lacaille made observations of Mars at the Cape of Good Hope, which were compared with others made at various observatories in Europe; and he deduced a parallax

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of about 10″. In the same century there occurred the two famous transits of Venus of 1761 and 1769, which were very extensively observed, among others by Captain Cook on his celebrated expedition for that purpose to the South Seas. Many and various were the results obtained by different discussions of the observations, lying between 8½″ and 9½″, but decidedly less than the parallax found from Mars; and we find that at the beginning of the 19th century the *Nautical Almanac* adopted a value in round numbers, 9″, as the best that could be made of them.

Values of the Solar Parallax used in the Nautical Almanac during the 19th Century.

	π
1801—1833	9″
1834—1869	8″·5776
Encke, from Transits of Venus, 1761 and 1769.	
1870—1881	8″·95
Leverrier, from Parallactic Inequality of Moon (1858).	
1882—1900	8″·848
Newcomb, from general mean of many methods (1867).	

In 1824 the German astronomer Encke submitted to a very searching examination the collected results of the transit of 1769, and deduced the result 8″·5776, which, with its imposing train of decimals intact, was incorporated in our *Nautical Almanac* for 1834, survived until 1869, and was responsible for the statement, which many of us can remember in the school books, that the distance of the Sun is 95,000,000 miles.

Meanwhile the attack upon the problem had been maintained in several different ways, and particularly by an indirect method that has many points of interest.

In the Lunar Theory there occurs, among the short-period perturbations to which the motion of the moon is subject, an inequality in a period of a month which depends upon the fact that the disturbing action of the Sun is greater on that half of the Moon's orbit which lies towards the Sun than upon the other half. The result of this is that the Moon is more than 2 minutes behind at first quarter and 2 minutes ahead at last quarter of the place which she would occupy were there no perturbation. It is clear that the magnitude of the effect must depend upon the ratio of the distances of the Sun and Moon from the Earth; and since the effect is large, an oscillation either way of about 125″, this should give a strong determination of the Solar Parallax, provided that the Moon can be observed with the required accuracy and that the theoretical relation between the perturbation and the Solar parallax is firmly established. In 1858 Leverrier found in this way a value of 8″·95; several other determinations supported this large value; and practically all the determinations made since 1830,

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however much they might disagree among themselves agreed at any rate in one thing, that Encke's value was much too small. We find, therefore, that in the *Nautical Almanac* for 1870, published in 1866, Leverrier's value 8″·95 is adopted, and the official distance of the Sun changed at one swoop from 95,000,000 to 91,000,000 miles.

But now preparations were in full swing for the observations of the Transits of Venus of 1874 and 1882, which for many years had been eagerly awaited in the full expectation and belief that then, with all the manifold improvements in the arts of observation, in the invention of the heliometer and the application of photography to celestial measurement, the question of the Solar Parallax would be definitely settled. We cannot do more than glance at the most beautiful and most complicated geometrical problems involved in the consideration of all the circumstances of a Transit of Venus. But these two diagrams* will show some of the circumstances of the very important phenomena, the times of internal contact at ingress and egress, the times when Venus is just completely on the Sun and just about to begin to go off. Great preparations were made for observing these times of ingress and egress, and the results would undoubtedly have been successful had it not been for the cruel way in which the geometrical sharpness of the phenomenon is ruined by the lighting up of the atmosphere of Venus; there was no instant when tangency was perceptible, and, to be frank, the Transit of Venus as a means of determining the distance of the Sun was a failure. The photographic and heliometer observations had for various reasons met with no better success than the observations of contacts; there was no consistency about the results.

But just as the preparations for the Transits were beginning in 1867, Prof. Simon Newcomb had published an elaborate discussion of the Solar Parallax based upon several different methods. With some of these we are already familiar, and I will call attention to one only, the last, which we have not as yet discussed.

Components of Newcomb's Value.

	π
Newcomb, Obs. of Mars, 1862...	8″·855
Hall, ,, ,, ...	8″·842
Hansen, Stone, and Newcomb, from Parallactic Inequality of Moon	8″·838
Newcomb, Lunar Equation of the Earth ...	8″·809
Powalky, Transit of Venus, 1769	8″·832
Foucault's Velocity of Light, and Struve's Aberration Const.	8″·860
Weighted Mean	8″·848

* Showing the passage of the Earth through the cones enveloping the Sun and Venus. (Not reproduced.—EDR.).

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It is an effect of aberration that every star describes yearly in the sky an ellipse of which the semi-major axis is about 20″·5, and this number is called the constant of aberration. It is the ratio of the velocity of the Earth in its orbit to the velocity of light. When the constant is known and the velocity of light is known, the velocity of the Earth in its orbit is known; and since the time of describing that orbit is also known, the size of the orbit and the distance of the Earth from the Sun follow immediately.

In 1876 it appeared then that there was strong evidence against the value 8″·95; and without waiting for the results of the Transit of Venus expeditions, the *Nautical Almanac* adopted for the while the value 8″·848 found by Newcomb from this galaxy of results which looked so accordant; and that value was first used in the Almanac for 1882, the year of the second transit.

But meanwhile Sir David Gill, who had observed the transit of 1874 at Mauritius and had made up his mind very definitely that no good would come out of the transit of 1882, had borrowed Lord Lindsay's heliometer and established himself on the island of Ascension to observe with the heliometer the opposition in 1877 of the planet Mars. Every night the observing station in Mars Bay was carried some six or seven thousand miles by the rotation of the Earth and the planet thereby displaced among the stars by some 40″. The heliometer is by far the most refined instrument for the visual measurement of distance from star to star; the observations extended over months instead of hours; they could be pursued without any of the disquieting feelings that a temporary breakdown would ruin everything; and they were brought to a successful end in a parallax of 8″·78. But one doubt was cast upon the result. Was it possible that the red colour of Mars had influenced the measures systematically? It could not be denied that the effect of the dispersion of the air, which gave the planet a blue fringe above that might be lost in the blue sky, and a red fringe below that would be indistinguishable from the red planet itself, might have produced some effect; and Sir David Gill resolved to try again, utilizing this time three minor planets further away than Mars, with less parallax therefore but with discs so small that they were indistinguishable from stars.

In 1888 and 1889, five observatories, the Cape in the Southern hemisphere, and Yale, Göttingen, Leipzig, and the Radcliffe Observatory at Oxford in the Northern hemisphere, combined to observe the planets Victoria, Iris and Sappho with the heliometer. The labour was immense. The observations proved to be so accurate that they demanded the use in a great part of the work of eight figure logarithms. When, only a few years ago, the whole work was published in two enormous volumes of Annals of the Cape Observatory, it might well have been thought that here was the last word

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of observation for many years. Yet we are now attacking the problem with more energy than ever!

About ten years ago the end of the century was in sight, and there was a general impression abroad that it was time to set one's house in order and to make a good start on the first of January, 1901. The directors of the four *Nautical Almanacs* (the British, French, German, and American) resolved to meet in Paris in 1896, and with the help of certain distinguished advisers to agree upon a uniform set of constants to be adopted in all the Almanacs from the year 1901. Among these constants was the Solar Parallax. We may summarize the information which was at the disposal of the conference thus:

Solar Parallax from	
Gill's Heliometer, Minor Planets	8″·802
Constant of Aberration of Light	8″·799
Parallactic Inequality of Moon...	8″·794
Mass of Earth from motion of Node of Venus alone	8″·762
,, ,, from secular var. of four inner planets	8″·759

Gill's heliometer measures of minor planets gave 8″·802, and no other direct observational result could be compared with this; the Transits of Venus were discredited even though some of the final results had not, and have not even now, been published. The most recent determinations of the constant of the aberration of light gave 8″·799, the parallactic inequality of the Moon, 8″·794. There were thus three powerful methods which converged upon a value close to 8″·80. But to set against them was a method which we have not yet noticed.

The perturbations in the motions of other planets produced by the Earth depend upon the mass of the Earth, and from them that mass can be determined. There is further a well-known relation between the mass of the Earth, the value of the gravitation constant, the length of the year, and the distance of the Sun, from which the latter may therefore be derived when we know the others. Prof. Newcomb had thus determined the parallax in two different ways, and had found two results agreeing closely among themselves, with mean 8″·76, but differing widely from the others. No explanation of this divergence could be found. But the evidence was 3 to 1 in favour of 8″·80, and 8″·80 was adopted in 1896 as the value to be used in all the Almanacs from the beginning of this century.

It might well have been thought that the question would have been allowed to rest there for a while. At the end of a century of labour four principal results had emerged, and there was a majority of 3 to 1 in favour of 8″·80. But there is a phenomenon, known in politics as the swing of the pendulum or the flowing tide, by whose operation a majority hardly won begins immediately to melt away. A like

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phenomenon appears to affect the Solar Parallax. We have seen how its adopted value has swung from 8″·57 to 8″·95, and back again to 8″·85 and 8″·80. Scarcely had the resolution of the Paris Conference been taken than the majority in favour of 8″·80 began to melt away. The beginning of the century had been chosen as an auspicious moment in which to make a change, without considering that there were at the end of the preceding century many investigations just then drawing to a close. The value of the Aberration Constant corresponding to 8″·80 is 20″·478. Almost every determination of that constant published since 1896—and there are many—had come out above 20″·50, many of these a long way above. Further investigation of the parallactic inequality of the Moon had not only altered the observed value of the inequality, but had modified the theoretical relation by which the parallax is deduced therefrom. The evidence for 8″·80 was giving way badly; and before the 1901 Almanac came into use, we had this revised table propounded by one of the chief instigators of the adoption of 8″·80. The majority was now 3 to 1 in favour of a value at least as low as 8″·77.

Revised Table.—Solar Parallax from

Gill's Heliometer, Minor Planets	8″·802
Constant of Aberration of Light	8″·77
Parallactic Inequality of Moon, probably ...	8″·77
Mass of Earth from secular variations	8″·759

I suppose that there will always be two opinions upon the question: Is the adopted value of the Solar Parallax to depend upon direct observation; or are the indirect determinations through the constant of aberration, the parallactic inequality, and the mass of the Earth to be allowed a weight in some proportion to their numbers? I take it that those of us who have determined the parallax by direct observations may not unnaturally look upon these indirect methods as interesting confirmations of our result, if they agree with it; while if they differ, there must be something wrong with them. But in the absence of a direct determination of overwhelming weight, there must always be a feeling of uneasiness when one sees three or more results conspiring to deny the truth of one. And however that may be, it is certainly true that about the year 1898 there was a very general suspicion abroad that the value 8″·80 was too large.

At this moment there came a curious stroke of fortune. Dr. Witt, of the Urania Sternwarte, Berlin, was engaged in a photographic search for a minor planet which had long been lost. He failed, but found instead a minor planet for which one would willingly barter the remaining five hundred odd; a minor planet indeed, but moving in a most remarkable orbit, lying for the most part within that of Mars, very eccentric, considerably inclined to the ecliptic, and approaching

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the Earth on favourable occasions within about 15,000,000 miles. It was immediately recognised that here was a new opportunity for determining the Solar Parallax, and that the determination must be made at once or left alone for thirty years, for a comparatively favourable opposition was due in 1900 and no more good ones till 1930 and 1937. At the meeting of the Permanent Committee which directs the making of the Astrographic Chart and Catalogue of the whole sky, it was resolved to invite a great co-operation of observatories to make a combined onslaught on the problem. The suggestion was readily taken up, with an alacrity indeed which might almost have suggested that the observatories concerned had nothing to do and were glad of a job, an imputation which is immediately rejected when one finds that some of the most energetic participants were precisely those observatories that had their hands most full with the astrographic chart (*Fig.* 1). By a cruel stroke of fate Sir David Gill at the Cape was compelled to remain a spectator of the work, for the planet came so far north that it was practically unobservable in the Southern Hemisphere, while in England we had the unique spectacle of a planet north of the zenith.

Fig. 2, borrowed from Prof. Wilson's articles in *Popular Astronomy*, shows very clearly the circumstances. Corresponding positions of the earth and the planet are joined, and if we follow out in imagination the directions that these lines must have, remembering that the orbit of the planet is inclined 10° to that of the Earth, we see that the planet described a loop at opposition, as all exterior planets do, but that the loop was of very unusual proportions (*Fig.* 3).

To discuss in any detail the circumstances of the apparition, and the way in which they can be utilized for a determination of the parallax, would take too long. But we may get a good idea of a fairly typical case by transplanting ourselves in imagination to the planet Eros on the evening of the 2nd of December, 1900, armed with an imaginary telescope ridiculously out of proportion to the real size of the planet, which is probably not more than 20 miles in diameter (*Fig.* 4). The Earth is past inferior conjunction with the Sun, and appears as a crescent. The North Pole of the Earth is tilted towards us, and by the aid of this projection of the meridians and parallels of latitude we can with great ease trace the path of each observatory as it is carried round by the rotation of the Earth, and can measure from the scales the angular distance at any moment of an observatory from the centre, or the distance between two observatories; which angular distances as seen from the planet are the precise equivalents of the parallactic displacements of the planet as seen from the Earth.

In the programme of observations there was one novel and promising feature—the application of photography. With the exception of the Transit of Venus observations, in which its success was not striking, photography had not been previously applied in a

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determination of the Solar parallax, for the very good reason that in 1889, at the time of the opposition of Victoria, there was practically only one telescope in existence which was capable of taking photographs for exact measurement, that pioneer photographic equatorial made by the Brothers Henry at Paris. The fact that there were in 1900 eighteen photographic telescopes engaged in observing Eros shows how rapidly the equipment of astronomy has grown in the last few years. We were so fortunate at Cambridge as to have our new photographic equatorial just completed and made to work. (I may remark parenthetically that it took longer to make the machine work than to build it, for when one embarks upon a large experiment, and sets up an instrument, the first of its kind, built upon improved lines, one sets out upon a sea of troubles.)

The great advantage of the photographic method in such an undertaking must be sufficiently well known by you. It is of course this, that one is rendered very much more independent of continued fine weather. A photograph of the planet and the surrounding stars could be made in 2 or 3 minutes of actual exposure. Given an hour's break in the clouds, one could accumulate far more valuable material than could be obtained in a whole night's visual observation, for the photograph once secured could be measured at leisure, by day or on cloudy nights.

Throughout Europe the skies of that winter were far from clear. I had the pleasure at Cambridge of sitting up from dusk till dawn for nearly three months on end, and during that time had not half-a-dozen nights clear right through. Had I been making visual observations I should have done little ; as things turned out I was able to get some 500 exposures. The programme was to get 4 exposures per hour throughout the night, making a number of exposures on each plate, and moving the plate a little between each exposure. The stars are then arranged in columns of fours ; the images of the planet, owing to its rapid motion, are in echelon.

Now each exposure gives very accurately the place of the planet with reference to the group of stars around it, and for merely parallax purposes the ideal would be to have pairs of such photographs taken at the same instant at stations widely separated. By a very simple use of the measures of some ten or twelve stars suitably disposed about the planet, it would be possible to allow almost automatically for the differences of refraction, orientation, scale value, etc., which make the plates not immediately comparable, and to find at once the parallactic displacement.

We have been speaking of the displacement as very large, and so it is when compared with the displacements dealt with in previous determinations. But look at it this way. We saw that the Earth as seen from Eros subtended an angle of 53″. The scale of the Cambridge plates is such that, if we draw a circle having a diameter of a little

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over 1½ mm., we represent the apparent diameter on our plate of the Earth as seen from Eros; and within that small circle the whole of the parallactic displacement must necessarily lie. About a millimètre was the average displacement obtained in a favourable combination of observations, and when we consider that we are trying to measure that with a resultant accuracy of 1 in 1,000, it does not seem so very great after all.

We have put the problem heretofore in its very simplest form. In actual fact the exposures at different stations were not simultaneous. Early morning observations made at Cambridge might be combinable with evening observations at Lick more or less simultaneous, or with evening observations 10 or 12 hours before at (say) Oxford; or they might have to stand alone. Any general method of utilizing all the results must secure the possibility of reducing each plate, so to speak, on its own merits, to allow it to contribute its quota, be it large parallactic displacement or none at all, to the general collection of equations of condition. This requires that we shall know the relative places of all those stars which are to be used as comparison stars for the planet, right along the whole track of the planet. And this derivation of a standard star system is by far the most delicate and difficult part of the whole work. One must start with a foundation of stars observed with the meridian circle, and fill in the fainter stars from the photographs themselves, taking care to provide at the same time the places of all those faint comparison stars which have been used by the visual observers. And all these places of stars must be tied together, so to speak, by the overlapping of the photographs, so that the system may run smoothly throughout its length. Absolute errors of zero there no doubt will be, and must be, but it is required that there shall be no sudden jumps in the errors exceeding one or two hundredths of a second of arc.

Now when one comes to face a problem like this one must enquire very carefully what is the real accuracy of the photograph. There is no doubt that the ordinary photographic telescope properly worked will repeat itself very well; it will take two plates of the same region which agree with one another excellently. But the question is,—How would two plates of the same region taken with different telescopes agree? We know that individual observers have peculiarities of their own which they can repeat almost *ad infinitum*. Does a photographic telescope do the same, or has it at last conquered that bad habit of idiosyncrasy which has made so much trouble in all refined astronomical work of the older kinds? When we started on the Eros campaign there was practically no information to be obtained upon this point. Almost all the photographic telescopes at work had been engaged upon their own zone of the chart, and almost nothing was known of how the results from different instruments would combine. But in our parallax problem this question is fundamental, and

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must be answered as soon as possible. I therefore ventured to propose to myself to undertake the reduction of a small section of the photographic results, for a period of 9 days in November, 1900, having before me two objects:—Firstly to discover how far it is possible to combine photographs taken at different observatories, how far, in fact, photographic telescopes are giving really accurate results or merely reproducing their own errors; secondly to obtain a provisional value of the Solar Parallax, with a probable error if possible as small as that found by Sir David Gill with the heliometer, and to find out provisionally whether Eros was going to confirm that result or to join in the secession from the adopted value.

Perhaps I may venture to think that the results of this enterprise have been in some measure successful. I found that as a general rule the results from different telescopes do not combine directly as well as could be hoped, and that there are many precautions which must be taken in using them, if we are to avoid serious systematic error and a ruination of the parallax determination. But I believe that it is possible to avoid these difficulties, and that the photographs properly treated will give a determination of the parallax of far greater accuracy than has hitherto been obtained. I found also that the 300 exposures in that period of nine days, contributed altogether by nine different observatories, gave a value of the Solar Parallax, $8''{\cdot}797 \pm 0{\cdot}0047$, which is in such nice agreement with Gill's $8''{\cdot}802 \pm 0{\cdot}005$ that one may feel in one's heart (though of course must never express the feeling so prematurely as this) some hope that, in adopting $8''{\cdot}80$ as the official value of the Solar Parallax, the conference of 1896 was not so wrong as some people have been prepared to believe.

	Distance of Sun in Miles.
From Heliometer Observations of Victoria, Iris, and Sappho. $\pi = 8''{\cdot}802 \pm 0''{\cdot}005$	92,875,000
From 295 *Photographs of Eros.* $\pi = 8''{\cdot}797 \pm 0''{\cdot}0047$	92,928,000

I cannot refrain from calling your attention to a by-product of this work which has for me a singular interest, because it seems to exhibit in a favourable light the accuracy which we may obtain with these photographic methods. After Eros had been under observation for some time it was discovered that its light was varying in a short period which was at first thought to be 2h. 38m. Afterwards it was found that the alternate minima of light was unequal, and that the true period should be reckoned as 5h. 16m., two equal maxima and two unequal minima being included within that space of time (*Fig.* 5). The variation appears to be continuous, without sensible

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pause, which precludes the idea that the planet is double and that the minima are due to eclipses of one body by the other. We must find some other cause. There are two which suggest themselves quite naturally—irregularity of shape and irregularity of surface brightness. For our purpose the important point is this, that either of these causes might produce an apparent oscillation in the place of the planet. To discover if this were so, I grouped the residuals in my equations of condition according to their epoch into eight columns, corresponding to successive eighths of the whole period of 5h. 16m., and took the means for each column. If there were a sensible oscillation in a period of 5h. 16m., these would lie on a sine curve. They obviously do not; there is no sensible oscillation in that period (*Fig.* 6). But notice that if we add together the 1st and 5th, the 2nd and 6th, and so on, that is to say if we search for the half period of 2h. 38m., we get quite strong evidence of periodicity (*Fig.* 7). Now the semi-amplitude of the oscillation is only 0″·03, a quantity so small that one cannot but feel doubts as to its reality. At first I was myself inclined to disbelieve; but when a new distribution of the residuals, starting from a different zero of time, gave a similar periodicity, it began to look as if there were something in it. The more I look at it, the more I believe that it is a reality; and that the photographs have shown themselves accurate enough to detect an inequality of 0″·03, corresponding to a shift of 5 miles at a distance of 25,000,000—by far the smallest inequality in the motion of a planet ever brought to light by observation.

It is this circumstance that encourages one to believe in the accuracy of the photographs. There are altogether 10,000 separate exposures of the planet which will within the next few years be measured and made available for discussion. If 300 give a P.E. of 0″·005, what will 10,000 give, added to 6,000 or 7,000 sets of visual observations? It would be going too far to apply the simple rules of probability and say a good deal less than 0″·001. But I fully believe that, if this great array of observations is ever submitted to complete discussion, the probable error of the result will not be much above 0″·001. And supposing that it should support with its greater weight the value 8″·80 which has been assailed, I believe that we should be justified in saying that the Solar Parallax *is* 8″·80, and in maintaining the proposition that the determination of the Solar Parallax is a problem of geometry and celestial surveying, and that upon the sponsors of the indirect methods lies the onus of showing cause for their disagreement.

This opens up an interesting prospect. Suppose that in course of time there should come to be a clear and definite agreement among the values found for the constant of the aberration of light, and that its value was (let us say) 20″·54, corresponding, as this table shows, to a parallax of 8″·77, not 8″·80, on the assumption at least that the

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velocity of light is exactly determined, as it seems to be, and that the simple theory of aberration is correct.

Relation between Solar Parallax and Constant of Aberration.

Ab.	π
20″·46	8″·808
·48	·799
·50	·790
·52	·782
·54	·773
·56	·764

And suppose that by that time we are prepared to say quite definitely that the geometrical value is not 8″·77 but 8″·80. The most obvious solution of the difficulty would be to conclude that the simple theory of aberration is not true, and to hand over the problem to the mathematical physicists, who might in the result find that a definite geometrical determination of the Solar Parallax had provided just the criterion which they required to settle certain vexed questions in dynamics.

Again, should further investigation confirm the conclusion that 8″·76 is the only value of the Solar Parallax which will reconcile the existing theory of the motion of the planet with the observed value of the constant of gravitation, it may be that the contradiction between the direct and the indirect methods will at last enable the dynamical astronomers to lay a finger upon that flaw which exists somewhere or other in the theory, and makes it impossible to say at the present time that all the motions of the solar system can be completely explained.

I have ventured to point out that the determination of the Solar Parallax is a problem of wide interest, since it throws upon so many different people the task of keeping up their particular end against an attack whose accuracy is gradually becoming more and more deadly. The dimensions of the Earth, as obtained by geodetic operations, are necessarily beyond the reach of any criticism derived from Solar Parallax results.

Equatorial Radius of Earth.

	Miles.
Méchain and Delambre, 1799	3961·74
Airy, 1830	3962·82
Everest, 1830	3962·67
Bessel, 1841	3962·76
Clarke, 1858	3963·31
,, 1866	3963·28
,, 1878	3963·37
,, 1880	3963·29

Extreme range of these determinations is only 1½ in 4,000.

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But it is interesting to speculate whether astronomers will ever be in the position to say:—"We have now determined the Solar Parallax in seconds of arc to a higher degree of accuracy than that of the measurement of the Earth," and to call upon geodesists for better results. I can conceive only one direction in which we may be able to worry the successors in your Corps of Everest and Clarke. Is the form of the equator a circle or an ellipse? I believe that there is some slight evidence for ellipticity, and that it has been put as high as one in three thousand. If that is so, it is just barely possible that we may have to introduce into the computation of the parallax factors for different observatories a term depending upon the shape of the equator. But I confess that this prospect is remote, and that for many years in all probability geodesists, who achieve accuracies of one in a hundred thousand and even talk of one in a million, will be able to take a serene view of the labours of astronomers to arrive at the distance of the Sun to one part in ten thousand.

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*RAILWAYS IN WAR.**

By Bt.-Lieut.-Colonel Sir E. Percy C. Girouard, k.c.m.g., d.s.o., R.E.

It will, I fear, be a somewhat difficult task for me to avoid treading old and perhaps familiar paths. So much has been written and published upon the use of railways in war, in these last few years. South Africa and the Far East would alone seem to have exhausted the subject. I trust, however, to be forgiven for any repetitions of former experience in the few new lights or ideas which it has been my endeavour to produce. To give any general review of the use of railways in war would both tax the reader's patience and entail a strain upon his appetite which I do not intend to inflict.

I have sought in this paper to emphasise a few of the guiding principles of the use of railways in war, and also to bring forward some new ideas on railway policy in our Colonial expansion and on the application of railways to siege attack.

The general principles which I propose to dwell upon are :—

(1). The organization most suited to insure the best results in war from the railways of one's own country, be they State or privately owned and worked.
(2). The working of railways in an enemy's country.
(3). The repairs or destruction of railways.

The reports of the work carried out on the railways during the late war in South Africa give the results of much experience and, may I say it, of hard work and loyal co-operation. That the reports sent home could not have been published *in extenso*, in the words of their authors and over their own signatures, is a matter of regret. Those of us who were more particularly engaged on that railway work must, however, be grateful for the excellent manner in which a *Detailed History of the Railways in the South African War* has been published by our Institute through the public spirit and generosity of its members. Whilst not forgetting the original authors, we owe our thanks to Capt. H. L. Pritchard, d.s.o., who collected and edited the reports in South Africa, to Major S. L. Craster, who expended much time and labour in abridging and rearranging them at the War Office, when it was supposed that they would be printed officially at the

* Lecture delivered at the Royal Engineers Institute on 23rd March, 1905.

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public expense, and to Major A. T. Moore, who eventually saw them through the press on behalf of the Institute.

In South Africa it was our duty

(1). To control and repair railways in a friendly country, with a friendly staff.
(2). To seize, repair and work railways in the enemy's country.
(3). In a minor degree, to construct new railways for war purposes.

MILITARY CONTROL OF RAILWAYS.

The first duty was that of controlling existing railways. To what degree will it be necessary? In war, how much or how little shall we exercise control? The reply on one very important matter is clear and trenchant—The experience of Continental wars and of South Africa definitely shows that the technical working "should not and must not be interfered with." The experience of these same wars shows just as conclusively that all railways within the sphere of operations, nay, within the country, must be under a distinct military control,—a control intended to assist in their working under war conditions, not to impede. The German and French Governments consider this control to have paramount influence upon the success of operations. Their regulations are exact and detailed. To the efficiency of these regulations must, in a large measure, be assigned the great success of the German arms in 1870-71; and to their inefficiency much of the French failure. In this regard the book by Jacqmin, "*Les Chemins de Fer pendant la Guerre de* 1870" contains much food for reflection.

Now what is to be the control? Simply this;—The army generally must not in war deal directly with the technical staff of railways, be they military or civil. There must be an intermediary staff, not to control locomotives or engineering, telegraphs or refreshments, but to convey to the operating or Traffic Staff the wishes of the General Staff of the Army.

The obvious method to meet this requirement is to parallel, so far as may be necessary, the traffic staff of the railways with a military controlling staff, General Manager, Chief Traffic Manager, Line Superintendents, Traffic Managers, Traffic Inspectors, Station Masters. This is carried out under Continental arrangements. It was applied under the Director of Railways in South Africa. Here were found Assistant Directors in touch with General Managers of civil or military worked systems; Deputy Assistants working with Traffic Managers; Railway Staff Officers with Traffic Inspectors or Station Masters. Their functions were frequently misunderstood by the army generally. Why not deal with the railway officials direct? The answer is to be found in the French experience of 1870-71 detailed by Jacqmin;—Orders and counter-orders were given direct to the civil staff by the

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General Staff, the Administrative Staff, Departments, and even the Minister of War; chaos and confusion ensued on all the Eastern lines; when the Prussians occupied Metz they found over 5,000 waggons, loaded and empty, inextricably mixed, and forming a complete block.

What would have been the condition in South Africa without a controlling staff, when our general staff methods were not always too clear, I must largely leave to the imagination of the reader of the French reports of 1870-71. There was in South Africa no general failure on the part of the railways to meet the requirements of the army. Partial failures did occur.

In South Africa complete controlling staffs existed (*a*) in the Cape Colony, dealing with their state-managed lines, and (*b*) in the two conquered states, where they dealt with the technical staff of the military railways, whose organization was in every way similar to that in the Cape. In Natal alone there was only partial military control of the state lines. The reasons for this difference I may not discuss. Fortunately, the partial control did not affect the general efficiency. That it was a mistake and might have been a grave one, when I presume it would have been rectified, must be admitted.

I have heard it said:—"Why all this controlling staff, these tiresome Railway Staff Officers, when we in Natal found the civil staff so easy to work with?" The Natal problem was fortunately a simple one. By February, 1900, the enemy had been driven out, and thereafter the troops stationed on these lines were few, the attacks of the enemy upon the lines rare, some 12 or 15 in two years; the Natal railways then became a line of supply only.

On the Cape side, throughout the war, troops were moving in all directions; columns crossed and recrossed the lines, pursuing the enemy; entraining for military operations was the order of the day in every direction and at points a thousand miles apart. To add to the difficulties the lines were blown up or attacked 300 times in 365 days. A fleet of 20 armoured trains cruised in various directions; originally piratical in their attacks upon the efficiency and capacity of the lines, by close co-ordination with the controlling staff they became an assistance rather than a hindrance to traffic efficiency. There were also specials of a permanent nature for senior officers; and a vast array of hospital trains, the Medical Officers in charge of which reasonably enough asked for precedence, but could not understand delay. Finally, cessation of night running for months. And there was another element which seriously affected the capacity of the lines—the demands of the civil population. On the Cape side, the Commander-in-Chief exercised, and rightly so, complete control. In Natal this was not the case; it cannot be said that advantage was taken of this, but it must have been a sore trial to carry military stores if at any time civil stores were on hand to

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go forward. The civil supplies paid three and four times the amount of rail carriage.

Throughout the war a staff of at times nearly 300 officers and men worked at the problem of so controlling all the elements against efficiency as to keep the lines up to their greatest capacity. They carried out their duties under very great disadvantages as to training and numbers. They were not always successful, nor invariably praised, but they saw the war through without serious interruptions. Looking back on their strenuous efforts, thinking what a failure of supply would have meant at a time when there were already quite enough difficulties and disasters, one can only regret that their efforts were not more fully appreciated. The success of the supply of the army depended upon them as a whole more than upon the technical staffs they co-operated with, who, though quite capable under ordinary circumstances of meeting the demands of a very large civil population, were by the nature of their training totally unfitted to satisfy military requirements and exigencies.*

I do not think it necessary to use any further arguments as to the necessity of a controlling staff in war. There may be few countries in which we will require it, as ordinary expeditionary railways can

* The lecturer at this point detailed a few of the many cases of interference with railway working in South Africa; these are amusing enough to look back upon, but at the time they afforded great annoyance and delay.

Shortly after the Natal line had been opened through to Pretoria, and at a time when the quick despatch of every truck load of supplies was of vital necessity, the Director of Railways was informed that the line had ceased working. On inquiry by telegraph, the block was found to have occurred at Standerton, where the engines had become stalled owing to lack of coal. There was ample coal available in a large stack; but on the civil staff attempting to remove it, they were informed that this could not be done as it formed "*the base of a military post connected with the defences.*"

The Delagoa Bay through line was at another period almost completely hung up under extraordinary circumstances. A large mob of cattle was driven in by our Columns and handed over to a Commanding Officer on the line of communications, with orders to send them on to Pretoria, some 80 miles away. The railway could not transport them, and the officer in question had no mounted troops at his disposal; an *impasse* thus appeared inevitable, when the happy inspiration occurred of escorting the cattle by armoured train. (Such trains were at that time outside the control of the Director of Railways). The result was inevitable; *the cattle moved at two miles an hour, so did the armoured train, and the railway in its entire length became blocked.*

South of Bloemfontein the mail train was found to lose time constantly at a certain station. On inquiry it was found that the delay was caused by the Commanding Officer attaching a four-wheel horse box to the train (a procedure entirely against the railway regulations) and proceeding with his horse to a point some ten miles south, where the train was stopped, the animal jumped out, and *horse and master took their evening exercise.*

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usually, by the smallness of their problem, look after themselves. In India, the appointment of Bt.-Lieut.-Colonel H. C. Nanton, R.E., who has had much experience of controlling work, as Assist. Quarter-master General, Railways (Mobilization), would indicate the adoption in that country of the most modern ideas in the use of railways.

There remains to be considered our own home question. At present we have an Army Railway Council and a Railway Volunteer Staff Corps. Both are mainly composed of the general managers of the great railways, who have been granted Lieut.-Colonel's or Colonel's rank. The great advantage of these organizations as general advisory bodies is undoubted.

But no general or detail regulations for the use of the English railways in case of invasion have been issued. The contingency of raid or invasion may be a very remote one, but it cannot be neglected. It is usually argued that our railways have such a vast capacity for carriage that they will have no difficulties whatever in meeting all requirements. I do not for one moment doubt this under ordinary conditions, but war and invasion will produce entirely different circumstances. The French railways, by no means inefficient, were, before a single Prussian had crossed the frontier, thrown into very great confusion by the multiplicity of orders they received; and by the time Sedan had capitulated they had become hopelessly blocked.

Imagine an enemy landed on our East coast, and making a rush to destroy the midland factories, on which our navy might largely depend, breaking all communications as they advanced. Orders and counter-orders would arise in every direction to increase the confusion to chaos, unless the railways had a definite military staff, possessing some knowledge of the railway systems, to which they could appeal. It is one matter to transport a bank holiday crowd of even 80,000 people, who take tickets and are subject to railway bye-laws; to handle, equip, and supply the vast number of brigades which might be mobilized in case of invasion would be quite another thing.

In France, dealing with a regular army and a supposedly efficient staff, the results were only too patent. In England the position would be infinitely worse. We would have to depend upon partly trained citizen soldiers and staffs; and in such a case, of how much value would the Army Railway Council be? The General Managers could not in war attend to its business as well as to their own. Certainly they would take the orders of its military members, the president of which, I presume, would become a Director of Railways; but in the absence of a controlling staff, who had studied in peace the various systems under this Director of Railways, and in war assisted the technical staffs and protected them, I must humbly contend that the General Managers would be quite impotent in their endeavours to carry out the orders of such a Director of Railways.

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Assuming such a contingency of invasion or raid, it is my firm opinion that, if it could be carried out even partially, the railways of England would be thrown into hopeless confusion in a very short space of time.

WORKING OF RAILWAYS IN ENEMY'S COUNTRY.

So much for the controlling of railways. Now a few words on the working of railways in an enemy's country, that is railways seized from the enemy.

They may be connected with lines under British control, as was the case in South Africa, or they may be distinct systems. The question as to how they are to be worked will depend upon how their staff behaves, *i.e.*, whether they can be trusted. If they can be trusted, as was largely the case in the Orange River Colony, take them over; if hostile, replace them at once, as we did with the officials of the Netherlands Railway.

If the systems taken over are small, and contiguous to important British lines, add them to the latter, and introduce a controlling staff. If they are large systems with central organization and contiguous, organize a new technical staff from General Manager downwards; the contiguous British lines will always assist, and a reasonable reserve kept up on the British or Colonial railways, or the army itself, will provide the remainder. By adopting this system, the working will be more directly under military control, and political difficulties will be avoided.

Lines seized as distinct systems present other difficulties; the staff, though not openly hostile, may be unsympathetic. Where practicable, replace them and give to the whole a new technical staff for the period of the war. Here more than ever is required an efficient controlling staff; possibly even knowledge of a foreign language may be essential to secure the best results in working. Certainly a portion of it should have studied the capacity and details of the particular lines in peace.

REPAIR AND DESTRUCTION OF RAILWAYS.

Successful reconstruction is a question of good staff organization in peace and ample staff and materials in war. The nucleus staff in peace may be very small, but it must know :—

1st. Where its additional staff will come from in war.
2nd. What is the nature of the railways it is to reconstruct.
3rd. Where the materials are to be obtained.

Reconstruction generally should be on simple lines. Complicated stores kept up in peace are therefore unnecessary.

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Three great impediments may be encountered, singly or in combination :—

(1). The wholesale destruction of permanent way.
(2). The wholesale destruction of bridges.
(3). The destruction or removal of rolling stock.

The first and third call for good reserves of rails and sleepers and of rolling stock respectively, or better still the knowledge of where they are to be found.

The second will resolve itself into the nature of the obstacles to be overcome. In South Africa fortunately the rivers, with few exceptions, carried but little water; their beds being often 60 feet below the level of the destroyed structure, it became a matter of deviations, with small bridges on piers constructed of rails and sleepers. When the rivers are deep and the volume of water considerable, great delay must ensue. If the beds are suited to pile driving, this form of bridge building, combined with deviations on sharp gradients, would appear the most expeditious. With hard bottoms will come the greatest delay, and then recourse must be had to concrete in bags. It is hoped that the Corps may be afforded opportunities in peace of practising, to some extent, upon these types of structure.

Finally, the destruction of railways. One method, and in most cases the most important, is that of blowing up every rail joint over long stretches of line. This is more or less effective in causing delay, according as to whether important structures (such as bridges and tunnels) can be easily turned.

In South Africa there were no tunnels of any importance, and the nature of the rivers did not make the bridge deviations as serious as might have been the case. If, on arrival at Bloemfontein, we had found the permanent way destroyed right down to Norvals Pont, it seems probable that a retirement of our entire army might have been necessary. Or if the enemy, in retiring north, had blown up every second rail joint from Dundee and from Bloemfontein, a rapid advance on our part would have become an impossibility. Between the 3rd May and 9th June, 1900, nearly 180 miles of reconstruction were completed north of Bloemfontein, involving the repair or deviation of 50 bridges but not more than three miles relaying of line. Had this entire 180 miles been destroyed, a very serious delay would have ensued. Fortunately 300 miles of new rails were available; but under such conditions as a continuous destruction, the opening for traffic earlier than November of this 180 miles to the Vaal river would have been a cause for sincere congratulation. This is the simplest and best form of effective destruction, where the line is not likely to be required by the destroyer or where an advancing force can effect it in rear of their opponents, an occurrence of a somewhat unlikely nature.

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In South Africa, the enemy was profuse in the use of dynamite—unnecessarily so. The bridges have to be rebuilt and paid for. Where deviations are possible the destruction of two spans and their piers is quite sufficient. Tunnels in rock should be left severely alone, though the blowing in of their portals, if driven through earth, will lead to some delay. Water supplies should be destroyed in the most thorough manner.

RAILWAYS AS AN ALTERNATIVE TO WAR.

There remains to draw attention to what is, perhaps, a somewhat new line of thought in the connection between railways and war. I have been dilating upon the use of railways during military operations; may I now ask consideration of their use as preventatives or minimisers of certain classes of such encounters.

There is little doubt that railways would in many cases obviate some descriptions of warfare only too well known to the British army—wars necessary for, or concomitants of, our Imperial expansion. There are some of our fellow subjects who doubt the wisdom of this expansion, past and present; but the *pros* and *cons* of Colonial policy do not come within the scope of this paper. The Empire has been and is committed to extension in many directions. Too often it would appear that such extensions have been carried out over several years of gallant but fruitless operations, entailing vast expenditure, when the pacification and establishment of order would have been more economically and permanently secured by the construction of a railway.

For instance, it is probable that the Soudan would never have been lost to us if the Nile Valley railway, originated in the seventies, had then been carried to Khartoum, instead of being left derelict as it was in a rock cutting some 60 miles south of Wady Halfa. Had this line been completed at its inception, the millions of expenditure of 1885 and subsequent years would probably have been unnecessary. To Lord Kitchener is due the entire credit of realising that the retention of the country and the success of a campaign would depend upon rail communication. The campaign of 1896–98 was the building of a railway with attendant military operations, rather than military operations with an attendant railway. The condition of the Soudan since 1898 is the proof of the wisdom of Lord Kitchener's policy. For such countries let the operations be those necessary to push a railway through and protect it; the cupidity of mankind will do the rest; trade will settle the country.

An example of the opposite treatment has been before our eyes for the last three years in Somaliland. To-day, after many gallant but, it must be acknowledged, somewhat fruitless attempts, are we much nearer our goal? The millions spent have been swallowed in the

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sands of the Haud, marked by the bleaching bones of camels and the unknown graves of Imperial soldiers. The £4,000,000 thus spent might have been devoted to railways and attendant operations, and to-day would be represented by a railway from Berbera to Khartoum, with a branch to Abyssinia, and the ultimate easy pacification and development of the country. In our West and East African possessions also, and in German South-West Africa, will be found the same want of appreciation of the real solution of the difficulty.

A railway is not to be looked upon as a universal panacea for all evils. But if we look back though the history of North, West, South-East, or North-East Africa, and place to the debit side of the account the huge sums spent in the Kaffir, Abyssinian, Egypt (1885), Ashanti and West African (since 1896), Central African, Rhodesian and Somaliland wars, we find a vast expenditure that would have fully provided sufficient funds to pacify the countries and develop their resources by pacific means. The Soudan campaign alone was carried out upon such lines, and left in its wake an asset in the form of 760 miles of railway which has enabled us to retain, develop and civilize the entire basin of the Nile.

The construction of lines for such purposes as the above should usually be undertaken in times of peace, in which case the design may be fairly left to those best fitted to judge of local requirements. Where they form part of an expedition depending upon the railway, as was the case in the Soudan, the constructors must have entirely different ideals. The main considerations must then be :—

(1). Rapidity of construction.
(2). Capacity to meet unusual strain.

In such work it will be found that the main difficulties are :—

(1). Staff.
(2). Maintenance of rolling stock.

To meet these you require a line worked by as small a staff as possible, and therefore by as few trains as possible. By having few trains you reduce the maintenance of rolling stock; your engine drivers, upon whom everything may depend, will be fewer in number and, it may be hoped, of a higher average of capacity. There is no use talking of long lengths of narrow gauge, with large numbers of trains and frequent stopping places; the staff will defeat you. In war, where a day's delay may mean a general expenditure of thousands, run no chances that the railway, if depended upon for communications, may be the cause. You require heavy engines and high capacity waggons,—little else will matter; if anything can, these will ensure the success of the line and the meeting of all army requirements, with a large factor of safety, and that factor one must have.

Where the gauge is not predetermined by existing lines, boldly

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adopt a reasonable one; remember that you can always obtain 4′ 8½″ gauge stock at any time, and by arrangement with India and the Colonies it would seem possible to inaugurate a reserve of mètre or 3′ 6″ stock. The mètre I cannot favour, the stock at present being much behind the times; but the 3′ 6″ of South Africa and Japan shows engines quite equal in power to many on the Indian 5′ 6″ and rolling stock of very high capacity. Why should we be afraid of these larger gauges? Curvature is no obstacle in most countries. In the Royal Arsenal you will see 4′ 8½″ gauge stock careering round curves of 250 ft. radius; in Natal, on 60-lb. rails, ten-coupled engines working round curves of 330 ft. radius combined with grades of $\frac{1}{30}$. This will meet your wants anywhere that you are ever likely to require war railways constructed in war.

Summing up this phase of railways, not so much for war, but intended to obviate or minimise it :—

It would seem desirable in developing new or savage countries, which also require pacification or the maintenance of order, to inaugurate a policy of railway construction. Where this development necessitates immediate operations, build your lines of high capacity as to train power. If the operations can be made subservient to the progress of the railway, adopt such a gauge as will ensure the slow pacification and occupation of the country, and provide for the future development of its resources.

The foregoing is not of universal application to war; it forms but a distinct characteristic of the requirements of an Empire developing like our own. Other nations in a lesser degree may find it applicable in Africa or elsewhere, but not in such a large number of instances as are certain to arise in our future progress.

RAILWAYS FOR SIEGE ATTACK.

The last application of railways to war, which I should like to bring to notice, is of a different nature altogether. It is not a question of finding means of transport for supplies or men, but the possible use of railways for siege attack. Siege operations have been rather at a discount for some years past. There are not many of us, but I feel sure there are some, who can remember a time when these were very much before the minds of officers of our Corps; they were then considered a very necessary part of our training as Royal Engineers. First and second artillery positions, the sap roller and the crowning of the covered way, seem to have sunk almost into oblivion, no doubt because sieges were not imminent. Port Arthur has, however, brought about a change, and once more we find that siege attack is about to become a pregnant question.

Consider any of the numerous great fortified Continental centres, which may occur to your minds, perhaps even be familiar to the eye.

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Would it be possible to undertake the attack of such places without railways to provide you with *matériel* and *personnel*? As a matter of fact railways run through practically one and all of them. Having your railway, why use as your battering force guns mounted on wheeled carriages? or why with infinite labour, as our allies have done at Port Arthur, construct narrow gauge railways to bring up the gun, the carriage, and the accessories of huge howitzers, which are then planted in one particular spot soon to be known to the enemy. It would appear to me much more reasonable to make these guns travel, and, as far as possible, fire from railway carriages of the ordinary gauge which is supplying you from your base.

Many objections will at once arise. Firstly, can the gun be thus fired? and what gun? In 1891 I had the pleasure of giving a lecture at the Royal United Service Institution upon the use of "Railways for Coast Defence." I had not much knowledge then, nor had anyone, of what could be done with guns on railway carriages. In the Royal Arsenal one could see guns, up to the 16.25 inch, firing daily in the direction of the line. On the question being submitted to Colonel Kensington, R.A., he gave as his opinion, after much consideration, that a 6-inch B.L. gun could be fired at right angles to a 4′ 8½″ gauge line, provided that girders were run out as in the case of cranes. It must be very satisfactory to Colonel Kensington to know that his theory has since been amply proved by practical experiment; at the time it was enunciated the average garrison gunner would not have granted it much support.

The South African War at one time threatened to produce a siege, that of Pretoria, where fairly modern forts with modern armaments were known to exist. At the same time the enemy at Modder River were giving us some trouble with their heavy artillery. The navy came to our rescue with heavy B.L. guns mounted on wheels. With a view to trying the use of the railway itself, it was pointed out that the railway department had both the shops and the goodwill to mount heavy guns if required. This offer was approved, and in a few weeks the two heaviest siege guns ever seen in the field were made ready. The carriages, designed by the combined wit of the machinery officers and the Chief Loco. Superintendent of the Cape Government Railway, were most creditable achievements, old engine and tender frames being utilised as a foundation. The guns mounted were a 6-inch B.L. and no less a monster than a 9.2-inch B.L. The 6-inch went into action at Modder River. It was deemed unsafe to fire it at an angle of more than 16° to either side of the centre line of the railway; but by placing it on a so-called firing curve a wider field of fire was secured. The gun behaved exceedingly well in every way; and later on it was fired at right angles to the railway, without any damage either to itself or to the line, which was of a 3′ 6″ gauge. The 9.2-inch gun was never in actual action, but it had ample practice

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and behaved well; if it had been necessary to use it against the 100-pr. guns of the Pretoria forts, for which purpose it could have been brought within range without constructing any new lines, there is little doubt that it would have given a good account of itself.

To return to our Continental fortress (I have one in my mind; a series of modern works surrounds a vitally important centre, which is approached by many lines of railway; the forts are often inconspicuous, largely armed with 6-inch guns, some behind steel or in cupolas). Proceed to attack any side of it. First your communication railways must be intact, a necessity in any case for ordinary siege attack. Proceed then to construct your first artillery position, involving primarily 20 miles of railway of the same gauge; heavy grades and sharp curves there may be, but on no side of the fortress is the task impossible; at most, three weeks should suffice for the construction of the base line of your first and last artillery position. Now come your guns, which can be anything up to the limit of what the bridges can stand, even the 12-inch B.L. if necessary; they can travel on main lines at the speed of ordinary trains. Your base line of railway will, of course, have been traced to secure good artillery positions. For the use of the heavy guns you may have to put down turntables, if you wish them to deal with more than one fort at a time; if not, ordinary curves will do. From the fire of the armament which exists to-day in all European land defences, such siege guns would be perfectly safe, in fact they would be out of range.

It is a fascinating study to take contoured maps, which are freely obtainable, and trace series of such proposed artillery positions. They are often of an almost ideal nature. And if you can further this study by actual visit to the ground, you will, I submit, be confirmed in the view that this form of siege artillery attack must be the system of the future.

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ORGANISATION OF ENGINEERS FOR AN INFANTRY DIVISION.

By MAJOR A. L. SCHREIBER, D.S.O., R.E.

IT is noticed that, in the few articles which have been published recently, all writers have agreed that at present the Field Company is insufficiently mobile, and each has suggested some means of progression for the sapper other than his own feet. With these opinions as to mobility I am somewhat at variance.

Most Engineers, who have served in the "Field," will probably agree generally with the proposals of Lieut.-Colonel Roper (in the April number of the *R.E. Journal*) for the organisation of the Engineers in an Infantry Division.

It is merely thought, however, that the items of his summary of the present organisation should be put in a different order of importance. First should come: "The C.R.E. does not form part of the Divisional Staff." Strictly speaking, this cannot be called a shortcoming "at present," as there is now no C.R.E. at all with a Division; yet we may express a hope that the previous arrangement will be reverted to.

I do not propose to deal now with the remaining items of the summary (with which I am generally in accord) other than the statement—"The company is not sufficiently mobile." This item, to my mind, should be placed last in importance. It could be understood if it referred to the fact that in many Divisions in South Africa a large and miscellaneous sort of Field Park was tacked on to the Field Company, rendering its transport cumbrous and unweildy. Since it refers to the *personnel*, its importance appears considerably overrated.

Mobility is a rather difficult question to discuss, as it must lead to a comparison between the tasks to be performed by the Engineers and by Infantry.

Taking the question generally, there is of course no doubt that the man who can be brought fresh to his job—whatever that may be, whether storming a position or digging a shelter trench—is infinitely more valuable than one who is already tired. Then comes the test of *morale*, courage, endurance, grit—whatever you like to call it.

No one can fail to be impressed with the superiority of a mounted force over a dismounted. Under many conditions this might even

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be put as ten to one. I believe that a Column of 1,000 good mounted men could, in South Africa, have harried, worried and rendered useless for all strategical purposes a whole Infantry Division with its squadron, field guns and cow guns thrown in. All that, however, is somewhat apart from the question under discussion. We are dealing with Engineers who have to serve with a force that marches on its feet.

Of course nothing would be nicer than to provide men with vehicles; but are they necessary? I have felt the greatest sympathy with the sapper, whom I once heard express his strong preference for a "third-class ride over a first-class walk," while bumping over the rough veldt on a springless buck wagon. But when we deal with warfare it is not a question of sympathy so much as one of necessity.

We may be inclined to look at our own mobility from too narrow a standpoint. Could not an infantry officer put forward the strongest reasons for means of conveyance on behalf of *his* men?

There is no doubt also that up to date our infantry have been unduly spared when the need for temporary defences has arisen. In future they must dig more than they have ever done before, and this is what the British soldier hates, be he infantryman or sapper. The main initial cause of the Majuba fiasco—the lack of temporary defences, due to the idea of sparing tired men—was probably at the root of several disasters that actually occurred in the late war in South Africa, and might well have produced hundreds of others.

It was hard enough on mounted men when, towards the end of the war, picquets were very rightly compelled to dig defences even for one night's halt. How much harder work therefore would be the lot of infantry, if they really took every precaution when in touch with a determined enemy.

On the line of march there is not much skilled work required of the Engineers; it is when a force is halted that their chief utility and technical skill are exhibited.

It may, however, be stated as an axiom that the sapper should march as light as possible, as all his strength *may* be required at any moment for manual labour. He should only take his arms and ammunition; his greatcoat, and rations even, should be carried for him. For this purpose each Section of a Field Company should have a light two-wheeled cart—Maltese, Scotch, or any other light pattern—to go with the "first line" and be always with the men. It is regretted that in the new *War Establishments* none of these very useful vehicles have been added, although the transport of a Field Company has been otherwise increased.

Another important point, so often neglected by the Staff, is that the Field Company should always be well to the front on the line of march. This point is mentioned in some notes, recently circulated, on the organisation of the Japanese army.

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When talking of mobility, it must be remembered that a dismounted party may be slow, but it is fairly sure and handy. Vehicles, whether drawn by horses or mules, or mechanically driven, are subject to many hindrances. The animals may die, the petrol may run short, or there may be merely a block on the road. Any transport officer can realize from experience the full meaning of the latter! How many times has the man on foot reached camp hours before the weary, cursing, broken-down transport—even of the "first line"—crawled in in the dark!

I put horses out of the question. We shall not get sufficient skilled workmen who can be trained to become moderate horsemen, and much less so moderate horsemen who are capable of becoming skilled workmen. It is true that there ought to be no reason why a skilled man of any trade should not be taught in a few months to sit on a quiet horse or pony going at a moderate pace. I cannot, however, help feeling that if our Field Companies were mounted they would deteriorate in technical skill.

The system may be carried out successfully with a small technical unit such as a Field Troop, but it would be impracticable with a larger body. In some ways and for some reason never yet discovered the horse has a peculiarly deteriorating effect on many men; it has a tendency to attract them away from their normal peaceful vocations! I have seen even non-combatants, when mounted and with feathers in their hats, appear the most truculent swashbucklers of the whole force.

Moreover, we must not omit to consider the additional animal rations, and consequently transport also, that any system of carrying men, whether riding or on wagons, would involve. Horse rations weigh about six times those of men's; they soon mount up, and any addition requires strong arguments to be justified.

The very important factor of the supply of animals themselves need only be mentioned.

Finally it is contended that, as far as I can discover, a Field Company has not yet been known to fail in mobility, and the only requirement is that all its men should march "light."

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*LANDING OPERATIONS AT THE ESSEX MANŒUVRES, 1904.**

THE total numbers landed were :—11,600 men, 2,700 horses, 61 guns and 315 wagons. These represented two Infantry Divisions, comprising :—

16 battalions of Infantry,
6 batteries of Field Artillery,
2 field companies of Engineers,
1 pontoon troop of Engineers,
1 telegraph section of Engineers,
2 companies of Mounted Infantry and Cyclists,
2 squadrons of Cavalry,

and a small Cavalry force of :—

1 regiment of Cavalry.
1 battery of Horse Artillery.

The whole force was embarked at Southampton in ten transports ; and steamed to the Essex coast in two divisions, each escorted by three cruisers.

The 1st Division disembarked at Little Holland and the 2nd Division at Clacton-on-Sea, the Cavalry force being distributed between them.

DEBARKATION OF 1ST DIVISION AT LITTLE HOLLAND.

By BT.-LIEUT.-COLONEL G. M. HEATH, D.S.O., R.E.

The point selected for the landing consisted of a cliff-bound shore. The beach had a slight slope which gradually flattened out below low-water mark ; in consequence boats could not be brought close in at low tide. The cliffs were about 30 feet high, of sand ; there was only one road up them, and this was steep, soft and unsuitable for heavy traffic.

On the first day of landing, 7th September, the sea was smooth and the conditions generally favourable. The five transports containing the 1st Division, with the three escorting cruisers, arrived in the early morning ; and were anchored soon after daylight, in line, about two miles from the beach.

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The first boats to put off contained a party of bluejackets without arms or escort. They landed on the beach at 7 a.m., and put up flags as marks to direct the various landing parties. At 8.15 a.m. steam pinnaces arrived, towing rafts and material for making landing stages, and with them about 15 armed marines. At 8.40 a.m. an infantry covering party arrived in five cutters towed by steam pinnaces; this party landed on the beach by a simple plank gangway put out from the bow of each boat.

Meanwhile the Navy were constructing landing stages for disembarking the remainder of the infantry. The first stage was completed at 9.20 a.m., and a cyclist company (the first troops to arrive after the covering party) was at once put ashore. The other stages were finished soon after, and the landing of the infantry proceeded with little interruption.

At about 10 a.m. the sappers of the Field Company, R.E., were landed with their tools and with materials for trestle or floating bridges, to improve the roads and to bridge the dykes in the neighbourhood as required.

At about this time the first loads of field guns, horses and wagons appeared. These were carried in flat-bottomed boats, usually two guns with their limbers, or two wagons, or ten horses in a boat. The boats are constructed so that the stern end can be let down to form a ramp on to the shore. The labour of unloading, which was very arduous, was provided by the Navy, assisted by fatigue parties of infantry. When the boats arrived near the shore, they dropped their anchors and ropes were taken out to them, by which the working parties on the beach hauled them in. It took seven minutes to off-load one boat load of guns and clear them from the beach. It took only two and a-half minutes to unload the horses after the gangway had been let down. The first wagons to arrive were not well handled, and it took twenty minutes to half an hour to haul one float ashore and unload it.

Landing Stages.—The landing stages for infantry were three in number, corresponding to the number of cruisers. They differed somewhat in detail.

No. 1 Stage (*Figs.* 1 and 2) was a combination of a floating structure (as pierhead) and a wheeled platform, with gangways between them and to the shore. The floating part was a raft, about 6 ft. × 10 ft., provided with handrails. The wheeled platform consisted of three planks battened together, supported on two spars which were carried on a gun carriage and limber. A boat was anchored end on as shown, and the infantry had to land over this boat on to the raft. This stage took about 1 hour to build. 25 men landed from it in 1½ minutes.

No. 2 Stage (*Figs.* 3 and 4) was all floating except for a short gangway to the shore. The pierhead consisted of two rafts, each 40 ft. × 9 ft., and allowed of two boats being unloaded at once. The

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rafts were connected by a narrow plank gangway (all floating) to the shore. It took rather over 1 hour to build, but was more efficient than the two other patterns. 80 men landed from this in 1½ minutes.

No. 3 Stage was much the same as No. 1, that is to say a 2-ft. 6-inch gangway floating on casks, terminating with a boat anchored stern on at the off-shore end. The gangway had better buoyancy and was more stable than No. 1. 101 men were landed in 4 minutes over this stage.

RE-EMBARKATION.

There was nothing particular to note in the re-embarkation at Little Holland, and no special gear appears to have been tried as at Clacton. The steepness of the ramps formed by the hinged ends of the boats proved a severe obstacle for loaded wagons. It took 10 minutes to load two guns and two limbers into a boat and get them clear of the beach, and about the same time to load up and haul out a horse-boat.

DEBARKATION OF HORSES AT LITTLE HOLLAND.

By CAPT. C. E. G. VESEY, R.E.

All the horses landed at Little Holland were brought from the transports to the beach in flat-bottomed horse-boats, from 3 to 5 boats being towed in strings or abreast by a steam pinnace.

The boats were each capable of holding 10 horses and from 12 to 16 men with their kits, harness and saddlery; and drew about two feet of water when fully loaded. The bow and stern were square; the stern end was made in two leaves, hinged at the bottom and centre, forming a gangway or ramp when lowered. When fully loaded with 10 horses sufficient space remained in the stern for the men, kits and harness. The bottom of the boat was covered with coir matting and additional mats were carried for the gangway. Each boat carried an anchor and cable in the bow.

The steam pinnace towed the boats as far in-shore as the state of the tide permitted; the towing lines were then cast loose and each boat cast its (bow) anchor off-shore. A line was then passed to the boat by the working party on the beach and made fast to the stern, and the boat was then hauled in stern first by the beach party, the direction being maintained by means of the cable in the bow. The men's kits, harness and saddlery were first passed ashore; the gangway was then lowered and the horses led out singly.

From 5 to 10 minutes were taken to unload one boat from the time it was beached. By lashing the boats 3 or 4 abreast and towing them in this formation the work was expedited, as the whole of the boats in tow of the pinnace could be beached at the same time and unloaded simultaneously. In one instance 4 boats were towed

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abreast, hauled in-shore together, and the 40 horses with men, kits, etc., disembarked in 5 minutes.

Horse-boats being available there was no practical difficulty in landing horses in the perfectly calm sea which prevailed on September 7th. But the hinged stern considerably weakens a boat when lowered to form a gangway, and the boats used would probably not have stood being beached with any surf breaking on the shore.

Points requiring Attention.—In loading horse-boats the horses should be placed with heads alternately to port and starboard. This was not done in every case.

Much confusion is avoided if saddlery and harness for each horse or pair is carefully packed in saddle blankets and distinctly labelled before leaving the transport. In some units corn sacks containing one set of harness were used for this purpose.

In disembarking transport and artillery the boats containing the teams should be towed ashore at the same time and beached at the same spot as the vehicles or guns to which they belong. This avoids having to man-handle wagons and guns to any distance ; if not done much confusion and crowding result, especially at night or where the beach is limited in breadth.

DEBARKATION OF 2ND DIVISION AND HORSES AT CLACTON.

By 2ND LIEUT. A. H. L. MOUNT, R.E.

INFANTRY.

The cruisers escorting the 2nd Division were the *Kent*, *Good Hope* and *Monmouth*. Each ship constructed one landing stage for infantry, the design being entrusted to the naval officers on board.

H.M.S. *Kent's* staging (*Figs.* 5 and 6) consisted of a wooden platform, 3 ft. wide, made of 12-inch × 1½-inch planks held together by cross battens, the whole supported on two naval 12-pr. gun-carriages and their limbers. Its total length was 80 ft.

The wheel base of the carriage is about 3 ft. 6 inches and the diameter of the wheels 3 ft. 9 inches. Each pair of carriages was connected by two 6-inch spars resting on frameworks of wooden blocks fixed to the axles ; the necessary depth was thus obtained for the carriages at the sea end of the staging. The cross battens were nailed to the spars when the latter had been placed in position, and the boarding was then nailed down to the battens. The trails of the gun-carriages were lashed up to the spars to prevent them dragging in the sand. The axles were connected with the ordinary rope braces used for man-handling the guns.

The axle of the front gun-carriage in deep water was secured to an 8 cwt. kedge anchor, some 200 yards out, by a rope passing round a single block on the anchor ring and made fast on shore. This carriage was also secured by cables to anchors on shore ; and in case

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of rough weather the other carriages would certainly have to be secured in like manner.

This form of staging is certainly the best, being *all* on wheels. By means of the rope round the block on the anchor it can be easily hauled out as the tide recedes.

H.M.S. *Good Hope's* staging (*Fig.* 7) consisted of a 3-ft. wooden platform of 12-inch × 1½-inch planks on 4-inch × 2-inch battens, all nailed together in lengths of 30 ft. The two shore bays were supported on two naval 12-pr. limbers; the other two bays were supported on two rafts, one of which was an ordinary temporary barrel raft and the other a naval copper punt raft. The bays were 15 ft. long, the total length including cutter being some 110 ft. The head of this staging was supported on a cross spar hung over the stern of a cutter. There were two cables, bow and stern, on each side of the cutter, made fast to anchors on shore. There were also cables on the rafts. A rope handrail was provided, being supported by wooden posts let into slots on the platform. This staging, having been previously fitted together, took 20 minutes to erect from the time the party of bluejackets (about 50 in number) landed with all the materials. 419 men were landed in 7 minutes; 273 men, with cooking utensils and other small baggage, took 11 minutes. The times varied a great deal according to the manner in which the string of boats was manipulated alongside the staging.

The apparent drawbacks to this staging were :—(1). The men had to get out of their boats into the cutter at the head; this is apt to cause confusion and delay, especially when landing the personal baggage, etc. (2). If the sea were at all rough a floating staging would be at a great disadvantage.

H.M.S. *Monmouth's* staging (*Figs.* 8 and 9). This consisted of two sections of 3-ft. wide platform, each 40 ft. long. Each section was in the form of a trussed beam, the struts being two barrels and the ties two strands of 1-inch wire cable. The central support consisted of a copper punt, and the head rested on the stern of a cutter.

A secondary idea of the barrels under the platform was to give extra buoyancy, but as it happened the stern of the cutter and the raft were too high out of the water to allow this object to be effected. The total length of the staging was about 115 ft. It was made fast to anchors on shore, and a rope handrail was provided.

It took 30 minutes to erect the stage with about 50 men. 180 men with personal baggage, etc., were landed in 20 minutes.

PONTOONS.

The pontoons were floated ashore with their carts, etc., complete underneath them; a pinnace towed 4 pontoons. The heavy anchors in the fore-carriages were put in the sterns of the boats, so as to tilt the bows up as much as possible.

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To sling the pontoons from the transports to the water, cables were made fast round the axles on each side and brought together above the centre of the pontoon.

CAVALRY.

Six landing places were arranged for receiving the flat-bottomed boats. At each place an 8-cwt. kedge anchor was dropped about 350 yds. out. A single block was made fast to the ring of the anchor, and two other blocks were secured on shore by holdfasts; and a $3\frac{1}{2}$-inch endless cable, 400 fathoms long, was passed round the three (*Fig.* 10).

Four or five of these boats were towed together by steam pinnaces from the transports to the buoys of the anchors. At low tide the cables were picked up by the boats, which were then hauled in, stern first and usually in pairs, by working parties of 30 infantry. When the tide was high the water was deep enough for the pinnaces to come right into shore, and so all this hauling was avoided.

The boats, which were 35 ft. × 15 ft., each carried 10 horses and their drivers and 4 bluejackets. On the average it took 7 or 8 minutes to unload one boat. One squadron landed 60 horses and all its kit in 30 minutes, working 2 horse-boats at a time.

ARTILLERY AND TRANSPORT.

The same system was employed for landing the Artillery and the General Service wagons. Each boat carried 2 guns and 2 limbers or 2 G.S. wagons. The guns and wagons were man-handled out of the boats by drag ropes, etc.

It should be noted that when loading the boats from the transports the poles of the wagons should point to the stern of the boat. This was not always done, and time was thus lost in getting the wagon out.

RE-EMBARKATION. 13TH TO 15TH SEPTEMBER.

Infantry.—The same stages were erected again, and the procedure was simply a reversal of the debarkation.

Cavalry.—No difficulty was experienced in getting the horses into the boats, though it took rather more time than the landing.

Loading Wagons into Horse-Boats.—First Method (*Fig.* 11).—The horse-boats were towed ashore and made fast to one of the kedge anchors 250 yds. out. The wagon was then hauled aboard backwards by 4 horses pulling on a cable which was passed round a single block in the bows of the boat and made fast to the rear axle of the wagon.

After a few experiments with this method it was found not altogether satisfactory. The horses could not be made to stop pulling at precisely the right moment, and so the wagons jammed. In fact it took just as long to get them on by this method as by man-handling.

Second Method.—At subsequent high tide, when there was no room for the horses, the wagons were partially unloaded and man-

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handled on board; they were put in pole first, as it was easier to guide them in this way.

It was found that the tailboard or ramp sagged considerably at the hinge when under the weight of a wagon; the consequence was that the gradient up to the boat was increased.

(N.B.—Separate ramps, which appeared to be heavy and clumsy, had been brought ashore with these horse-boats; but for some reason they were never used either in landing or re-embarking).

Loading Battery of Field Artillery.—Three boats were brought up alongside each other, and 2 guns and 2 limbers were loaded into each. The guns were brought up as in *Fig.* 11, and loaded on by bluejackets; the horses being unharnessed and taken on for loading on to their own boats at the same time. One team was kept till the end loading one boat by the block and tackle method; but this method was again found to be no quicker than man-handling.

From start to clearing the beach the whole battery with its G.S. wagons and 79 horses (in 8 horse-boats) was embarked in 35 minutes.

GENERAL REMARKS.

By BT.-LIEUT.-COLONEL G. M. HEATH, D.S.O., R.E.

On the first day of landing, the first party to reach the shore consisted of an officer with a few bluejackets, unarmed, who began to arrange landing stages. A covering party did not appear until 1½ hours afterwards.

It seemed to me that the small floating landing stages would have been useless in any but quite calm water. Undoubtedly the best type was the one which was carried entirely on wheels, thus making a stable platform in anything but very rough sea.

The stages as a whole seemed to me to be too small; they were only suitable for landing infantry. But infantry could have been landed on the shelving beach more easily and much more quickly by rowing the boats, line abreast, right on to the beach, and then putting out simple plank gangways over the bows, as was done for the covering party at Little Holland. (Possibly this method would not have done for the large boats which contained 100 men, but it would have been applicable to all the cutters).

If landing stages are made at all it would seem that they should be substantial structures (say 8 feet wide) to which several boats can be brought up, alongside, at one time; and that they should also be capable of use for off-loading stores of all sorts. It would not be difficult to design a stage consisting of trestles, road-bearers and chesses, the trestles being adapted to take wheels so as to allow of the whole structure being pushed out or pulled in according to the flow of the tide.

The steepness of the hinged gangways which formed part of the

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flat-bottomed boats was very noticeable. A pair of troughs (say 10 feet long) to guide the wheels, clawed on to the end of the boat, would have made the embarkation and disembarkation less laborious.

The Navy took charge of landing operations up to high-water mark. Their beach party consisted of a senior officer as Beach Master, and under him officers and working parties of bluejackets. At Clacton and Little Holland there were not enough bluejackets to carry out the off-loading, and their working parties had to be supplemented by fatigue parties from the troops already landed. I was told that, in theory, the fatigue parties from the Army would not be available, as they would be required with their regiments. In practice I should think troops would always be required to help at the landing of their transport wagons.

On the first day of the landing the combination of bluejackets and soldiers was not worked to the best advantage. Want of organization was evident, and in consequence labour was wasted. For instance, at Clacton I saw about 150 men on a single rope pulling a wagon out of a boat, while other boats which were ready to be off-loaded were waiting for labour; probably 50 men would have been ample on each boat. It seemed to me that things worked much better in the re-embarkation, when I believe a senior military officer was deputed to work with the naval Beach Master. The former officer should, I think, be one with experience of handling working parties; he would then know how to distribute the available labour to the best advantage.

After the wagons were landed there was often delay in getting them away from the beach. As noticed by Capt. Vesey, guns and their horses should be (and I think generally were) landed together. Compliance with this principle in the case of transport wagons is probably impossible with the large number accompanying an invading force. The only solution would seem to be to have fatigue parties of horses told off for beach duties; the horses would park the wagons in a suitable place clear of the shore.

The method of landing and re-embarking the pontoons as described by Lieut. Mount was most satisfactory. In re-embarking care must be taken that the wagons are not driven into the sea fully horsed. This was done by the first pontoon wagons, with the result that the leaders got out of their depth and there was some difficulty in unhooking them.

The nature of the landing place at Little Holland emphasised the necessity of disembarking Engineers early in the operations. The only road up the cliff was in bad order; also a trestle bridge had to be made across a dyke to facilitate the movements of the guns; this bridge was constructed by the 7th (Field) Company, R.E., in 45 minutes.

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SEARCH LIGHTS IN RECENT NIGHT OPERATIONS AT CHATHAM.

SOME very interesting operations took place at Chatham on the nights of 10th October and 21st November, 1904. The special idea resulted in attacks on Fort X. The Training Battalion, R.E., under Bt.-Colonel A. Graham Thomson, formed the defending force; whilst the attackers, under the command of Bt.-Lieut.-Colonel G. M. Heath, D.S.O., R.E., comprised the Service Battalion, R.E., the 1st Batt. Welsh Regt., the 2nd Batt. Oxfordshire Light Infantry, the 4th Batt. Rifle Brigade, and the Chatham Division of Royal Marine Light Infantry. The defenders were given two days to prepare their position, and made full use of their inventive talents in the shape of barbed wire entanglements, trip wires with flares or rockets (representing mines), etc. The most interesting lessons were in the use and effect of search lights.

REMARKS BY MAJOR F. BAYLAY, R.E., *Instructor in Electricity, S.M.E.*

So far as this report is concerned the operations on each occasion consisted of a night attack upon Fort X from the eastward. Search lights were used both with the attack and with the defence.

On each occasion the principal attack was delivered on the right (or south) flank of the Fort, under cover of the steep bank on that side. The attack made use of smoke-producing bonfires, lighted on the slope referred to, the smoke from which drifted in a northerly direction right between Attackers and Defenders, and formed a highly efficient screen so far as the search lights were concerned. This screen was particularly effective on 10th October, and was on that occasion assisted by the black powder used by some of the Attacking force. On the 21st November the strong wind blew the smoke away more rapidly, and the screen was, I believe, far less effective.

OPERATIONS ON 10TH OCTOBER.

On this date the operations lasted from 6.30 p.m. to 9.15 p.m. The night was fine, overcast, slightly hazy and dark, with a gentle breeze from the southward; quite dark at 6.30 p.m.

With the Attack was employed the Wolseley Pack Transport plant and 30-c.m. projector, the whole mounted in a G.S. (R.E.) wagon

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borrowed for the occasion and drawn by two pairs of horses. The projector was one of those returned from South Africa and was a General Electric Co. (U.S.A.) outfit ;—30-c.m. Mangin projector, 8° diverging lens, 10 to 15-ampère automatic horizontal lamp. This outfit has no plain glass door, but the night was so still that it was possible to use the light without the diverging lens.

The Wolseley set got into position about 1,200 yards east of Fort X, at 7.5 p.m., with instructions to dazzle the Defence as far as possible. It took 15 minutes to "get ready" ; but for some reason, not ascertained, it took one hour to get the plant running ; once fairly started the engine ran well until the end of the operations.

It was at once seen that the light, either with or without diverging lens, was far too weak to be of any value at that distance ; and after running for about 20 minutes, the plant was moved to 400 yards from the Fort. As great difficulty had been experienced in starting the set it was considered undesirable to stop it, and with some persuasion one pair of horses was yoked in without shutting down the engine but with light switched off.

The light ran for half an hour at the second position. At this distance an observer close to the projector (diverging lens on) could just distinguish the parapet of the Fort *during the operations*. A few minutes after operations ceased the smoke cleared off and the parapet could be seen with great clearness. I am informed that the blinding effect of this light upon the Defence was negligible, and my own opinion is that the light was useless. (*Vide* General Conclusions).

I see no reason to think that the plant could not have been got into the first position in actual warfare. (See also below). When there, since it served as little better than a "beacon" so far as concerned Fort X, it might possibly have been disabled by gun fire even at that distance. During the advance to the second position, the wagon was in the (diverged) beam of the defence light nearly all the time. Those with the wagon appeared brightly illuminated to one another, but so far as I have been able to ascertain the advance was *not* observed by the Defence. Possibly the Defence may have casually observed a wagon moving in the field and have imagined it to be a farm vehicle. It seems rather impossible to think that the wagon could really have been advanced at the walk ; and even if the light had been got to the second position, I fancy it could not have been operated there for long.

With the Defence was employed the Thornycroft Automobile plant and 90-c.m. Crompton projector. The projector, on its 2-wheeled vehicle, was placed outside the extreme right flank of the Fort, so as to look over the parapet of the outwork there. The projector had a 90-c.m. palladium reflector in good order and a 90-ampère automatic horizontal lamp ; and arrangements had been made to fit a 30° diverging lens, which was used throughout the operations.

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The Thornycroft wagon drew itself and projector vehicle from the Electrical School, but the projector vehicle had to be manhandled across the field behind the Fort. There was some difficulty in starting up the engine again ; this was traced to insufficient charge in the ignition battery ; once started the ignition can be, and usually is, effected by magneto. The light was started about 6.45 p.m. and ran well till 9.15 p.m., when, just at the end of operations, a bearing seized in the gear box and the engine pulled up ; this laid up the engine for some days.

Owing to a hedge running across the front of the Fort at from 400 to 700 yards distance, the Defence light could not illuminate the *ground* east of these hedges, so that anything beyond them, less than about 4′ 6″ high, was not lighted up. While the Attack light party was getting into its first position from the main road it was in the beam from the Defence light. Rifle fire had only just commenced ; smoke bonfires had not yet been kindled. The Attack party and wagon, from 4′ 6″ upwards, were brightly illuminated. I have however been unable to ascertain that they were observed by the Defence. The Defence light was principally used to illuminate the ground close to the front of the Fort, and for that purpose was considered to have been efficient. Assuming that the attack got to within 300 yards of this light (this was the sort of range at which it was used), I do not believe it would have been really practicable to have kept the light going. (*Vide* General Conclusions).

OPERATIONS ON 21ST NOVEMBER.

On 21st November the operations lasted from 5.30 p.m. to 8 p.m. The night was clear, full moon, brisk breeze from S.S.W. The wind freshened during the operations and the sky clouded over until, at about 8 p.m., there was a strong breeze, and at 8.15 p.m. the rain came down in torrents for half an hour or so.

The Attack had the Thornycroft Crompton set at the first position of the previous occasion ; and the Wolseley plant, with 60-c.m. Siemens projector, in an advanced position about 400 yards south of the former second site and 500 from the Fort. The Defence was provided with two 60-c.m. Coast Defence type Schuckert projectors on the two flanks of the Fort, both supplied off a service 16-unit dynamo, mounted in a heavy traction engine tender behind the gorge, and belt driven by a large Fowler traction engine.

The Thornycroft plant drew its own equipment complete from the Electrical School, leaving there at 3.45 p.m., and the engine was kept running without a stop till 9.20 p.m. The engine ran quite satisfactorily. The ground in the fields was hard and dry, but it was necessary to unlimber the projector and manhandle it into position for the last 50 yards. The light was started without difficulty (time

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not noted), and ran very well until stopped about 8 p.m. The heavy rain storm, previously referred to, came on shortly before the projector vehicle was limbered up.

The "train" started homewards satisfactorily; but in trying to get on to a cart track, the hind wheels of the Thornycroft wagon got into a slight dip in the ground and skidded, and the procession halted. For an hour efforts were made to get clear, but without success. The heavy rain on the hard dry ground made the clay-like top surface extremely slippery, so that the driving wheels could not get sufficient grip. The weather cleared up during the night, and next morning the ground was frozen. This enabled the plant to get itself out after about 2½ hours' labour (four men). One and a-half hours of this was spent in heating up the vapouriser, a by no means easy operation with the strong cold wind blowing at the time. This incident, and the inability of the Thornycroft set to pull itself and projector vehicle into position on the previous night (and on 10th October) over a fair track with a gradient of about $\frac{1}{50}$, are worth noting as points against mechanically propelled portable plant, particularly if engine power is scanty. Mechanical transport enthusiasts will perhaps argue that the vehicle would have come out all right on the night 21st—22nd November if "so and so" had been done. As the rear axle of the Thornycroft wagon is "live," my own opinion is that the vehicle could have pulled itself out had there been available a few fathoms of 2-inch manilla rope and a 56-lb. anchor.

As the first position was 1,200 yards from Fort X, I deemed it desirable to start the light there as a concentrated beam, with its right-hand limit aligned on the northern Defence light. Allowing for three degrees divergence the beam would be about 65 yards wide at the Fort, and might, it was anticipated, have a dazzling effect upon the Defence. The upper portion of the parapet of the Fort was illuminated by this beam well enough to be fairly visible to an observer at the second position (400 yards from the Fort), but I am informed that the dazzling effect on the Defence was negligible. I was unable to return to the first position until after the cessation of operations, so the light there ran as a concentrated beam all through.

The Wolseley plant was horse drawn to its site, started up under the cover of a hollow there, and manhandled into final position. The wind was so strong on the edge of the ridge, that it was only with difficulty that the blow lamp (required for heating up vapouriser) could be got to work at all. However, as soon as the vapourizer was heated the engine started at once. Unfortunately the lamp operator (one of a class under instruction) allowed the lamp carbons to come together while the wagon was being manhandled into position, and the engine was pulled up. The cold wind cooled down the vapourizer so quickly that, before the engine could be re-started, the blow lamp had to be got going again. The engine was on its best behaviour,

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started again promptly, and ran well and steadily, giving about 25 to 28 ampères (rather over normal full load).

As this plant had on 10th October given too weak a beam, I decided to commence with a concentrated beam. The beam obtained with 25-ampère arc in 60-c.m. projector was very good. A high building, 1,400 yards off, could be seen very clearly by an observer alongside the projector. My intention was to use this beam to dazzle the defenders in the neighbourhood of their right light. I believe this object was in no way attained, although the distance between the opposing lights was only 500 yards. I do not believe it would have been really practicable to work this light at such close range. The gear in the wagon was so cramped that I deemed it undesirable to attempt to change to diverging lens with engine running. (*Vide* General Conclusions).

The Defence lights were each given by a 60-ampère Schuckert horizontal automatic lamp in 60-c.m. projector, fitted with 16° diverging lens. They worked admirably as it happened; but had the rain come on sooner, there would certainly have been trouble with the belt drive between engine and dynamo.

Both Defence lights were principally, if not entirely, used for short range work (about 300 yards), and for that purpose were considered to have been efficient. I do not believe it would have been possible to keep these lights going if the Attack had got within that range. (*Vide* General Conclusions).

GENERAL CONCLUSIONS.

I was unable to attend the conference after the operations of 10th October, and have not heard what comments, if any, were then made about the search lights. At the meeting on the morning of 22nd November opinions were expressed that the Defence lights had been very useful in lighting up the Attacking forces; but that the Attack lights were valueless to the Attack and their beams at times served as an illuminated background against which the Attackers stood out and were then visible to the Defence. The Attack lights were considered not to have been used to the best advantage, the advanced light being handled in a particularly eccentric manner.

I believe it was thought that the Attack lights would have been better employed had they been placed on the flanks of the Attack, and arrangements made to throw their beams across the front of the Defence, so as to form a brightly illuminated screen behind which the Attackers could operate. Having regard to the formation of the ground and to the short distance between the Defence and the Attack working parties, I do not think it would have been possible to use the Attack lights in that manner; although, had it been possible, the screen would, no doubt, have been effective, particularly as the driving

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smoke would have given "body" to the screen. As an alternative, it has been suggested that the Attack lights would have been more effective had they been kept flashing backwards and forwards across the front of the Defence; if this had been done, it would not have much mattered if the Attackers had been momentarily lighted up by their own lights. I think this is a more practical suggestion than the other.

For the Defence, search lights are of undoubted utility. With a concentrated beam it may be possible for trained observers to detect movements of troops at considerable distances, say 1,000 to 1,500 yards; and from these distances it is believed to be difficult to hit the projector. It is however at the short ranges that Defence lights are likely to be of most value. For short ranges a diverged beam gives a sufficiently intense light, and for that purpose a parabola ellipse reflector would seem preferable to paraboloid reflector and diverging lens; the former would render practicable, for such positions as Fort X, the use of bullet-proof protection for projector and reflector, without absolutely preventing the beam from being traversed. I believe some such protection would be essential for a light operated at short ranges.

The utility of search lights for the Attack is less obvious. Unless the Attack is so deliberate that appliances similar to those used by the Defence can be employed, it is probable that Attack lights must always be used at relatively long ranges; hence concentrated beams are required. A concentrated beam is a cone of light rays with a divergence of about 3 degrees. When operating over flat country, like that to the east of Fort X, it is only practicable to usefully employ the bottom part of the cone; otherwise the Attackers are lighted up by their own lights. This means that a comparatively small portion of the beam is usefully employed, the greater portion of it passing over the heads of the Defence. (This was noticeable on the 10th October and on 21st November; particularly so in the case of the advanced light on the latter date). This drawback would be greatly eliminated if it were possible to place the projector some 10 or 15 feet above the general ground level; failing this, Attack lights would probably only be of value when they operated over ground that was concave. Unless the section of the ground over which the beam was used were concave, a diverging lens would not help matters much, if at all, even if the Attack light got close enough to the Defence for a diverged beam to give the requisite intensity of illumination.

Although, speaking generally, such lights may be of doubtful utility for field use compared with their use for coast defence, some of the continental powers, Germany in particular, have made provision for quite a number of portable Electric Light sets for field use. Such plant to be of any value should, I consider, furnish not less than a 60-ampère light in a 60-c.m. projector.

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REMARKS BY BT.-COLONEL A. GRAHAM THOMSON, R.E.

The Defence lights were, I think, sited to the best advantage to meet the existing circumstances; but their full value could not be tested owing to buildings and numerous hedges in close proximity to the line of defence, which would all have been certainly demolished in actual warfare. It must also be remembered that it is very doubtful whether Fort X itself would have been strongly held at the outset of operations; probably much more use would have been made of low relief entrenchments in advance of the Fort itself. These entrenchments would not have shown up as a mark for the enemy's artillery and would have been little damaged by it; with a cleared field of fire, and with obstacles immediately in front, they would have been most difficult and costly to assault.

Getting as close to the Defence lights as the Attackers actually did, it is doubtful whether the lights would not have been hopelessly out of action. But taking for granted that the ground in front had been cleared, it would in reality have been a much more difficult operation at night to locate the lights exactly and put them out of action. It would, however, appear that some kind of shield is required to give a certain amount of protection against shrapnel to the operators and to the lights themselves.

There is no doubt that the smoke raised by the Attack on the first occasion was most useful to them; but as the men engaged on this operation could be clearly seen at times, they would probably have all been shot down. The high wind in November dissipated the smoke to such a degree that the resulting fog was practically innocuous to the Defence.

The small search light with the Attack in October was quite useless, as it did not either dazzle the Defence or light up the ground to its disadvantage. I might mention that its position at about 400 yards was accurately found by a range-finder in the Fort, and it would no doubt have been early out of action.

The search lights with the Attack in November were, I consider, of much more advantage to the Defence than to the Attack; as on several occasions they showed up the enemy's advance and their working parties without dazzling or annoying the Defence to any appreciable extent. This was particularly noticeable where a canvas screen had been erected, the Attackers behind it being clearly silhouetted on the screen.

I am of opinion that where it is possible to use the Attack lights on the flanks, there would be the most suitable place for them. At the same time the flashing backward and forward would no doubt be disconcerting and I should like to see the effect actually tried at manœuvres.

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The Defence lights shewed up the wire-cutting parties of the enemy so distinctly that their losses must have been very heavy, and their success somewhat limited.

REMARKS BY BT.-LIEUT.-COLONEL G. M. HEATH, D.S.O., R.E.

The value of search lights in Defence is obvious.

Search lights for Attack purposes can, I think, seldom be of much value in the close attack unless the configuration of the ground happens to be favourable. They must however be a great help in reconnoitring the Defender's position by showing up obstacles and works, thus to a certain extent guiding the Attacking parties.

There will always be some danger of the Attack lights showing up their own side, and for this reason they must be intelligently directed by officers who are cognisant of the proposed operations. Each light should, if possible, be in signalling or telephone communication with the officer directing the Attack. I doubt whether it would often be possible to use the lights on the flank of an Attack so as to throw a screening beam across and in advance of the Attackers.

Smoke forms an effective screen when wind and weather are favourable. The simplest way of producing the smoke seems to be by means of sandbags stuffed rather tightly with dry straw, the ends of the bags being left open and the canvas slashed here and there to allow the smoke to get out. They should be lit in the centre of the straw by pushing in a port fire. Such bags can be carried with working or covering parties and thrown to the front; they burn for about 20 minutes.

I think the whole subject of "lights" in attack and defence requires more study than it gets, also more practice.

A Search Light Company has now been organised at Aldershot. This will work tactically with the troops and much useful information should be gained.

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THE ARMY SYSTEM OF CORRESPONDENCE.

By Capt. H. Musgrave, R.E.

It is unhappily no rare occurrence to hear complaints of the trouble and delay involved in conducting business in the Army through the medium of correspondence, and it is to be feared that such complaints are not always without justification. The object of these notes is to show that much of this creaking of the wheels of the military machine is due to the method of correspondence adopted, and that much good would result from the substitution of the ordinary system employed in civil life.

In the Army the usual system of official correspondence is the minuting system; in the conduct of civil business the method of separate letters and replies is adopted. In the latter system the sender of a letter takes a copy of it (if he requires one) before its despatch (employing mechanical means, such as carbon paper or a copying process, for the purpose), and the recipient guards the letter and sends a separate reply, of which he, in his turn, keeps a duplicate, both parties being thus automatically provided with a complete record of the negotiation.

Generally speaking, communication by writing is employed in lieu of verbal conversation only with one or both of the following objects;—firstly, for the immediate purpose of concluding a piece of business in spite of the impossibility of, or without the inconvenience of, or the risk of misunderstanding and oversight incident to, verbal negotiations; secondly, for the ulterior purpose of providing for future reference a permanent record of the transaction. In the humble opinion of the writer, the minuting system is, in comparison with the ordinary civil one, a far more laborious and tedious method of fulfilling the first-named purpose, and incomparably inferior as a means of accomplishing the second. Further, it is submitted that the minuting system exercises what may be termed a vicious influence, by lending itself to slipshod methods of conducting business.

To proceed first to establish the charge of inefficiency in the fulfilment of the essential objects of correspondence as defined above.

As regards the first-quoted object, viz.: the immediate purpose of concluding a question as speedily and satisfactorily as possible, the following are the principal defects of the system:—

(*a*). The facts of a case under discussion are presented to the reader in the form of a bulky collection of minutes; many of these

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contain much that is immaterial to the last reader; many convey no meaning except when read in conjunction with other minutes, and in exactly the proper sequence with respect to such other minutes; and, further, a large number, consisting only of such words as "passed," "forwarded," etc., furnish no information whatsoever. All this matter has to be waded through and sifted out before a clear grasp of the essential points can be obtained when first dealing with the case, and even, to some extent, when it is merely a question of refreshing the memory. If a file comes round more than once, it is often a matter of some trouble to discover what has been added to it since it was last seen.

All this demands a far greater amount of time and trouble than if the points requiring the attention of the reader were concisely stated in one clear letter without any irrelevant matter at all. In the minuting system, moreover, every person to whom a file goes has independently to go through this laborious process of wading through and mentally summarising the contents; whereas in the business system, if a fresh party has to be consulted on a case he receives a single clear statement of the necessary information, and this can be readily drafted by reference to the last letter summarising the subject matter up to date.

(*b*). Much needless mechanical labour is involved in making copies, or *précis* in registers, of minutes which have to be returned; such *précis* are often very badly made and frequently useless. This is one of the worst points of the system. In any correspondence of importance it is essential to keep records of the contents of communications which pass. In the minute system this has to be done by making *précis* or copies of all fresh minutes which reach an office, as well as of those written from the office. In the business system, where the sender keeps a duplicate of what he has written and does not expect the return of his letter, there is practically no copying whatever, since the duplicates of outgoing letters are provided by mechanical devices with little more trouble than if the letters were written in single, whilst the incoming letters are not copied but are retained. The minuting system also gives much unnecessary labour in "noting and returning" communications which, in the ordinary way, would need no acknowledgment at all.

(*c*). When, as sometimes occurs, two or three different batches of minutes on the same subject are going the rounds simultaneously, there is almost certain to be confusion and working at cross purposes, owing to the habit engendered of only considering a minute in connection with papers actually pinned up with it.

(*d*). Except at times when the batch of minutes on a question happens to be passing through the office, it is difficult to readily verify the existing position of affairs, unless, of course, the laborious recording referred to in (*b*) has been very completely carried out on

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loose sheets of paper pinned up together to form a duplicate file and not scattered in the orthodox way throughout the pages of a cumbrous register; such recording work is usually impossible. This is frequently an inconvenience, as, for example, when an interview, concerning a question under discussion, takes place at an office where the file does not happen to be resting at the moment.

(*e*). It often happens that several different points in a case might be dealt with simultaneously. Under the minuting system this is discouraged. The file is started round to clear up one point and nothing is done as regards any others until the return of the file, when it is sent on another journey in connection with a second point. The principles of "one thing at a time" and "out of sight, out of mind" are thus combined in a most pernicious manner, and lead to a vast amount of needless delay. A similar and very common case is when several persons have to be written to on precisely the same point, and the file is passed round to them all in turn, whereas all might have been written to direct and simultaneously.

(*f*). When, in the course of a correspondence, a "fresh hare" is started, it is a fortunate and rare occurrence for the original question to get settled at all until the fresh one has been thrashed out,—simply because the minutes on the first matter get dragged about with the discussion on the new question, to the complete neglect of the former.

(*g*). Though without any direct bearing on the question of efficiency, it may be added that the minuting system causes the despatch by post of a very needlessly large weight of paper.

As regards the second object which has been ascribed to correspondence, *i.e.*, the provision of records, the shortcomings of the minuting system are equally serious,—except when the established practice of confining the records of passing correspondence to entries in a register is departed from, and the clerical labour referred to under (*b*) above is carried to the point of making complete duplicates of files, an undertaking which is impossible with the usual clerical establishments of the smaller offices. Excluding the case of the office where the file ultimately finds its resting-place (generally, by the way, a head office, because, no matter where the discussion originated, the tendency is for the head office to arrange to have the file sent to it in the end, as much to save the trouble of making careful *précis* there as to centralise what records exist), the only record in any of the offices concerned consists of the *précis* which are supposed to be kept in the Correspondence Register. Owing to the labour involved in making *précis*, and also to the fact that the number of clerks is small who can be trusted to make clear intelligent ones without omitting any essential points, these digests are as a rule badly compiled.

It may here be noted incidentally that, under the *précis* system,

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the evil effect of the temporary employment of a bad clerk is irremediable, whereas, under the system of guarding letters, any disorder the correspondence may get into can easily be rectified at any time. Again, even if the *précis* in the register are well kept, with cross references and index, they form a very cumbrous record. It is a trying business to hunt out the course of a correspondence by referring to entries scattered throughout a massive book. The sole readily available record comes, in practice, to be the memory of the staff in the office, and when the staff changes all knowledge of the matter disappears for practical purposes. Even in the office where batches of minutes are actually filed, it is almost impossible to guard and index a batch, in which several subjects have been dealt with, in such a manner that any one new to the office will be able to lay his hands readily on all matter bearing on any question which may come up again.

This absence of readily accessible records leads to great want of continuity; questions are uselessly raised anew which have in fact already been thoroughly discussed and settled, and instructions are neglected simply through ignorance of their existence. Waste of labour and loss of efficiency must naturally result.

In the above remarks attention has been confined to the inherent defects of the minuting system and their effect on the conduct of business. It may, perhaps, be worth while to consider also certain ways in which the system may tend to influence the manner in which work is approached, even though such influence may not be inseparable from it.

Since it is the custom to deal with correspondence by adding a minute to the previous remarks of others and then forwarding the file again, a feeling is apt to be engendered that no one is responsible for doing anything, in regard to a question under discussion, except the individual who happens to be in possession of the file for the moment. Such a view would undoubtedly be welcomed by anyone wishing to shirk trouble; the system provides him with a ready means of getting rid of a question and shifting the responsibility by just minuting the papers, on any pretext, to someone else; and after having done this he would consider himself in a position to reply indignantly to a reminder on the subject, by stating that the papers were "passed to the X.Y.Z. on such and such a date." It is almost like some parlour game; the thing is to avoid being caught in possession of the file; so long as one can do this, though it may not expedite the settlement of the business, one can have peace with honour—can shirk trouble without incurring rebuke for inaction.

The custom of passing on correspondence often leads to the result that officers, who might take an active and helpful part in the settlement, fail to do so, not altogether intentionally, but through sheer force of habit. Thus it may happen that the decision of a question

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which is being discussed along a chain of command may be really only influenced by the highest and the lowest in the chain, the officers in between not taking any active part. This may sometimes be right; but in certain cases it must tend to an undue amount of work and responsibility being thrown on the lowest subordinate in the chain, who perhaps does not possess all the information necessary to decide it in the best way. In this manner the interpretation of the precise meaning of ambiguously worded instructions may fall on some one very far removed from the office from which they originated, instead of the ambiguity being cleared up at the first step. Much needless paper work also results from this forwarding on of minutes which might be dealt with where they are.

The habit thus leads to three distinct evils,—wrong division of labour, loss of efficiency through the abilities of intermediate officers not being brought to bear, and unnecessary clerical work. If officers, instead of minuting on the minutes of others, had themselves to redraft in full all their letters, these evils would be avoided, because they would then pay more attention to the clearness, conciseness, completeness, reasonableness and necessity of their communications.

In conclusion, the following point is perhaps worth consideration. The power of marshalling facts and expressing opinions in clear, concise and unambiguous language is undoubtedly of great value to officers, and should be developed in every way possible. It can be confidently stated that a system of correspondence by single letters would do more to cultivate this power than the present system, under which officers are confined to expressing themselves in disjointed comments, conveying nothing to a reader until he has first laboriously mastered a mass of equally laconic contributions evolved in the earlier stages of the discussion.

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THE THAMES BARRAGE SCHEME.

A Plea for Suspended Judgment.

By Brevet Colonel O. E. Ruck, R.E.

Of the many complex engineering schemes which now and again suggest themselves to the fertile imaginative brains of the pioneers of progress, this scheme must be classed as amongst those of the most alluring type.

Analogous to those fascinating projects, already foreshadowed out of the mists of the distant future, such as the Clyde and Forth Ship Canal, the English Channel Overhead Bridge, and the like, the Thames Barrage Scheme appears to be one well worthy of leisurely consideration at the hands of all those practical authorities whose technical experience may shed some degree of light on the general question, now wrapped up in partial obscurity.

It is owing to its extraordinary complexity that this scheme presents such varied interest to the public at large. Many men, who would, as a rule, prefer to rank themselves on the side of the angels, and hold aloof from an intricate expert engineering problem such as this presents, are finding themselves drawn in and freely ventilating their opinions, with a degree of warmth quite unusual in such nebulous matters. And why should this be so ? unless it be that, as in questions concerning theological doctrines or spiritualistic conundrums, so few clearly defined practical data are accessible from which to form a sound judgment ; and the field for elasticity in argument is so vast, presents so tempting an arena for the naturally combative logician, that discussion becomes irresistible. Most men, those in the street and those without, merchants and their clerks, railway men, dock men, shipping men, engineers (amateur, civil and military), landowners, farmers, pilots, bargees and politicians, each and all seem anxious to have their say in the matter. In fact the question is a national one.

In the absence of previous engineering experience of works on a small scale similar to the proposed Barrage, all who may be concerned have a right to contribute to the discussion the results of their own personal experience ; more especially so, as the life of the Thames has been from time immemorial so intimately bound up with the life of the nation itself.

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In the erection of such a work as a Great Barrage, it is advisable to look not only for a means which will present the fewest elements of uncertainty during construction, but still more for one which will be most convenient and will give most satisfaction to the greatest number of interests. As to the controversial side which has been evoked by the suggestion to construct a Barrage, many obscure points have been discussed with commendable vigour. Some of these, in fact the majority, can only be decided by actual trial; very little, if any, evidence has been taken based on previous experience of similar structures, for the excellent reason that they do not exist. The barrage over the Charles River at Boston, U.S.A., has been quoted, but the case is not on all fours with that over the Thames. Each criticism has been academically, if not practically, met in argument, but no hard solid facts have been adduced in support.

The exploiters and their critics have gravitated into two hostile camps, and the one side has only to assert an affirmative to be at once countered by the other side with a direct negative. Ordinary geese are magically converted into prime swans, dressed up, decorated and consigned, ready cooked, for the particular market aimed at.

The pro-Barrage exponents affirm that dredging has the effect of causing serious damage to the riparian owners, by the subsidence and flooding of their land; their anti-Barrage opponents carefully explain how river banks cannot be expected to hold up the lacustrine water of the dammed-up Thames basin, without letting it through in fathomless oceans to inundate the adjacent property. This is in reality a simple matter of ordinary engineering experience, and can be decided without argument.

The paramount question as to whether the Barrage should be constructed at any particular point on the river's course (say at Gravesend), or whether it might not be more advantageously placed at some other point lower down the Thames—say half-way down the Lower Hope Reach—does not appear ever to have been broached; there is much to be said, looking forward to the future, in favour of the latter site. The anti-barrage party criticise nothing but the plan, the actual original plan for a barrage at Gravesend, with its four midstream central locks; no modifications or alterations to meet alternative conditions or sites are apparently permitted.

No evidence seems to have been elicited, as to the economical handling of goods in bulk alongside river jetties scattered over a long length of lineal quayage, as compared with the dealing with a similar quantity of goods unloaded at open docks on a large scale, such as would be the case if the large area of marshland on the lower Kent and Essex flats were dockised. This concentration of open docks could be effected most readily were the barrage to be sited lower down the river than at Gravesend. Some capital has been made of the danger of interference with the tidal column and the disturbance

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of the normal sequence of the laws of nature; but the science of engineering has many times before now crippled the powers of nature for mischief, directing them into well-defined channels and subjugating them to its own will.

The military aspect of the question is also one which appears to be open to many shades of opinion.

As regards interference by the Barrage with the navigational facilities now afforded by open water, the number of craft passing a given point in the twenty-four hours is considerable, and will in the future be a constantly increasing quantity, especially if all sorts and sizes are included; but no suggestion has been made to relieve the pressure on the central locks by alternative methods. This would seem to be a comparatively simple matter by the construction of bye-passes, in the form of short ship canals through the marshes and round the shore ends of the barrage. A brief study of the plans of the Mersey docks and the Harbour Board inside the docks at Liverpool and parallel to the river walls will at once shew what a large amount of traffic can be dealt with expeditiously in this way. The continuous concentration of dredging on to one well-defined channel, such as in the Queen's channel and on the bar of the main approach to the Port of Liverpool, also shews how much can be done in this line to keep the main channel clear for vessels of the deepest draft, in case of a tendency to silting.

The present state of affairs on the Thames appears to have arisen from a curious combination of circumstances pressing for some united action and decision. The Royal Commission, appointed in 1901 to enquire into what is known as the Port of London question, found that in the next ten years the sum of £2,500,000 must be expended in improving the river channels and £4,500,000 on improving the existing docks and constructing new ones; they also recommended the formation of a central controlling authority. But as no less than 56 more or less rival authorities were concerned in the management of the Port at the time, the question assumed a thorny and complicated aspect, especially as an entirely novel and taking scheme for constructing a barrage over the river pushed itself to the front and claimed attention. It is therefore not surprising that the delay to shipping, want of dock accommodation, and expense in handling goods still continues. In the meantime the increase of tonnage of vessels clearing and entering the port steadily goes on.

The Barrage scheme, which has been estimated at various sums under £5,000,000 but based (so far as can be determined) on somewhat intangible data, was originally proposed with a view to saving the very large amount of dredging necessitated under other schemes. The Barrage would also save the London County Council, as the central authority for a Port of London Commission, from the necessity of purchasing the existing docks and warehouses at a cost of about

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32 millions, which would have the effect of increasing the dues of all using the Port as well as adding to the usual rates. Whilst these complicated questions are under consideration, the traffic of the Port will tend to increase, that is up to a certain point; meanwhile the technical problems involved in the Barrage scheme, the Improved Deep Water River Jetty schemes, and any others, may be thought out. But after a certain amount of time has elapsed, the shipping authorities will begin to find that the existing conditions are becoming unbearable; the traffic will tend to diminish; and unless a fair modicum of improvement is constantly going on, other ports will become the ultimate beneficiaries to the detriment of the Port of London.

But as everything in this world is subject to the laws of perpetual change, in engineering as in other matters, time will probably bring its own solution in disentangling this irritating *impasse*. The stern law of necessity will enforce its potent sway. Money spent in dredging, training-walls and jetties will not be wasted. And if the barrage scheme, by virtue of living examples of similar structures on a smaller scale, can eventually assert its undoubted claims for practical consideration, it is thought that the Port of London will still continue to hold its own in the prominent position it now occupies as the Premier Port of the world's carrying trade.

The *pros* and *cons* of the details of the Great Thames Barrage scheme at Gravesend will be found argued out in full, to the extent of our present knowledge of the subject, in the following pamphlets, etc.:—

(1). *The Great Thames Barrage*, by T. W. Barber, M.INST.C.E., St. Bride's Press, Fleet Street.

(2). *Remarks on the Proposed Barrage Scheme*, by Mr. J. G. Broodbank, Secretary, London and India Dock Company, 54, Threadneedle Street, E.C.

(3). *Public Works* Magazine, Vols. IV. and V.

(4). *The Royal Engineers Journal*, January and April, 1905, in articles entitled "The Future of London," by Lieut.-Colonel J. Winn, late R.E., and Colonel H. P. Knight, late R.E.

(5). *Daily Mail Year Book* for 1905, page 177.

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TURBINES ON ATLANTIC STEAMERS.

By COLONEL L. F. BROWN, LATE R.E.

PERHAPS the following particulars of the latest adaptation of the turbine engine to an ocean steamer may prove interesting to the readers of the *Royal Engineers Journal.*

I write this on board the Allan Line R.M.S. *Virginian*, now just completing her second voyage across the Atlantic between Montreal and Liverpool. She is a vessel of 12,000 tons, and fitted with Parson's turbine engines of 12,000 horse-power. At her trial trip she developed 15,000 H.P. and made 19·8 knots, but she runs her course across the Atlantic at a steady 16 knots, whether it be in the smooth waters of the St. Lawrence or in the wild rollers of the Atlantic.

The first thing that strikes one when on board is the total absence of any sense that there is any engine power on the ship; there is no throb of engines nor any vibration. Several times when we were going at full speed, passengers asked "Are we going along?" In the rough seas also there is no racing of the screw, nor that unpleasant wagging of the tail that one feels in most ocean steamers. I remember once, coming home in the *Teutonic*, that it was impossible to read or write on account of the excessive vibration.

The *Virginian* has three screws actuated by three turbines. The centre turbine is high-pressure and the steam passes from it to the two outer turbines which are low-pressure; from these latter it passes to condensers, and thence is forced back as water into the boiler again. When going at 16 knots the high-pressure turbine was supplied with steam at 125 lbs. pressure, and the three turbines were making from 240 to 250 revolutions a minute. The two low-pressure turbines revolve outwards, and the centre turbine revolves in the same direction as the starboard one. The shafts of all three screws are 12 inches in diameter, and the screws are of less diameter than those of an ordinary steamer, which would be going at about 80 revolutions for the same speed. The steam enters at the forward end of each turbine, and thereby takes most of the thrust of the screw shaft.

The blades of the turbines, which number altogether about a million and a-half, are all $\frac{3}{4}$ inch wide and increase in length from $\frac{3}{4}$ inch to 8 inches as the pressure diminishes. They are all of gun metal or phosphor bronze, and it is estimated that each blade has to stand a pressure of about 1 lb. The turbines are each about 8 feet long. The diameter of the central turbine is 5 feet 6 inches and that of the outer

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ones 8 feet 6 inches. The two outer turbines have an extension under the same jacket of about 4 feet; this contains the reversing turbines which, when not in use, act as a fly wheel to the driving turbines. The central screw does not reverse. The supply of steam to the engines is regulated by the usual governor balls.

In the engine room nothing seems to be moving except the various small engines that are doing work inside the ship, and the room is cool, in fact almost cold. A gentle humming can be heard in the turbines, but that is all. There are no men anxiously oiling various moving parts; the only thing to oil is the screw shaft, and that is oiled automatically. One man was in the engine room.

As to whether the turbine is more economical than an ordinary engine in an ocean passage, it is difficult yet to say. The only figures I could arrive at on this question is that a fully laden steamer of 12,000 tons can be driven at 16 knots on from 180 to 200 tons of Canadian coal a day.

As far as the passengers are concerned a turbine steamer is far more pleasant to travel in than an ordinary one. I am writing this in a heavy gale and there is not the slightest vibration or racing of the screw to be felt in the ship.

R.M.S. *Virginian*, 2. 6. 05.

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TRANSCRIPTS.

ANCIENT DEFINITION OF AN ENGINEER.*

Engineer, in the military art, an able, expert man, who, by a perfect knowledge in mathematics, delineates upon paper, or marks upon the ground, all sorts of forts, and other works proper for offence and defence. He should understand the art of fortification, so as to be able, not only to discover the defects of a place, but to find a remedy proper for them, as also how to make an attack upon, as well as to defend, the place. Engineers are extremely necessary for these purposes: wherefore it is requisite that, besides being ingenious, they should be brave in proportion. When at a siege the engineers have narrowly surveyed the place, they are to make their report to the general, by acquainting him which part they adjudge the weakest, and where approaches may be made with most success. Their business is also to delineate the lines of circumvallation and contravallation, taking all the advantages of the ground; to mark out the trenches, places of arms, batteries, and lodgments, taking care that none of their works be flanked or discovered from the place. After making a faithful report to the general of what is a doing, the engineers are to demand a sufficient number of workmen and utensils, and whatever else is necessary.

* We are indebted to Major M. A. Cameron, C.M.G., late R.E., for this transcript from *A New and Complete Dictionary of Arts and Sciences*, by a Society of Gentlemen. Published by W. Owen, at Homer's Head, in Fleet Street. 2nd edition. 1763.

An identical article appears in *The British Encyclopedia, or Dictionary of Arts and Sciences; comprising an accurate and popular view of the present improved state of human knowledge*, by William Nicholson. Published by Longman, Hurst, Rees, & Orme, Paternoster Row, 1809.

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HOSPITAL TRAINS IN WAR.*

Classification of Trains.

The hospital train service, as used during the campaign, may be classified as follows:—

1. *Hospital Trains.*

Specially fitted, equipped, and staffed as such, for conveyance of lying-down cases; corresponding to the Austrian "sanitätszüge." Of these there were two kinds—

(*a*). Converted ordinary trains. The following (all, in fact, save the "Princess Christian") belong to this category—

No. 1 Hospital Train.
No. 1A „ „
No. 2 „ „
No. 3 „ „
No. 4 „ „
No. 5 „ „
No. 6, an abandoned Boer train.

(*b*). One specially built ("Princess Christian").

2. *Improvised Hospital Trains.*

As a rule, first-class corridor car trains, unaltered, often with a kitchen car, for conveyance of less severe cases and convalescents, corresponding to "krankenzüge." A Medical Officer, provided with medical comforts and a small stock of medical and surgical materials, accompanied each convoy of sick, but there was no permanent staff.

3. *Ambulance Coaches.*

In addition, there were a number of specially-fitted carriages placed at convenient intervals on the railways. These were used to pick up small parties of sick from the various posts along the lines, and were attached to passing trains for conveyance to the nearest hospital. Many of these had a regular service, usually twice a week up and down their own stretch of line. Some of these carriages were provided with the usual iron frames for support of the service stretchers. Others were similar in construction to the converted hospital train carriages.

Staff.—As a rule, one N.C. Officer and one orderly were attached for duty to these carriages, and the Medical Officers along lines of communication attended to the wants of the sick as the carriages passed the various posts.

* Extracts from *Report on the Medical Arrangements in the South African War*, by Surg.-General Sir W. D. Wilson, K.C.M.G.

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HOSPITAL TRAINS PROPER.

Construction.—No. 1 Train was prepared in Natal and was ready at the outbreak of the war. A little later No. 1A was also got ready. These trains were not elaborately prepared, and very little expense was incurred in their preparation. Ordinary passenger carriages were selected; these were not gutted nor supplied with new fittings; only very slight alterations were made. The doorways were left unaltered, and there was no through communication from end to end of the trains. Special narrow stretchers had to be used for conveyance of the patients into and out of the carriages.

Hospital Trains Nos. 2, 3, and 5 were constructed at Cape Town. Nos. 3 and 5 carried 92 lying-down cases in addition to staff; No. 2, 96.

The following description of No. 5 will serve for all three; the only difference between the trains consisted in the fact that the ward-cars in No. 5 were all converted passenger cars, in the others, partly passenger, partly post-office cars. As passenger and post-office cars were much the same size and shape, and both had to be completely gutted of all internal fittings before conversion, the distinction is of slender importance.

Like all the ambulance trains employed during the war, with the exception of the "Princess Christian," No. 5 Ambulance Train was improvised from ordinary railway rolling stock. The train was made up of seven coaches with through communication from end to end, arranged in the following order:—

(1). First-class saloon car, for medical and nursing staff.
(2). Kitchen car, with pharmacy and orderlies' room.
(3). Ward of 24 beds.
(4). „ „
(5). „ „
(6). Ward of 20 beds, four of which were screened off for Officers.
(7). Pack and steward's store car, with space for guard.

The train carried 92 lying-down patients, and a staff averaging 22. All the vehicles, with the exception of the kitchen car, were converted Cape Government Railway "bogey" coaches; (1) being a first-class corridor saloon car but little altered; (3), (4), (5), and (6), third-class corridor cars, which had been completely gutted and fitted up with two double-tiered rows of wooden bunks, arranged longitudinally with central passages; (7), an ordinary luggage and guard's van, one end of which was fitted with a steward's store-room and meat safe, the other with shelves and lockers for kits. With the exception of (7), 20 tons, the tonnage of each car was 24, making a total of 164 tons, a weight requiring a "first-class" engine for most parts of the South African lines and two engines for certain long, steep gradients such as the Hex River and Lootsberg passes. The tonnage of a train, in connection with the hauling power of the engine and the gradients of the line, is one of the most important factors to be taken into consideration in the construction of ambulance trains; every increase in weight through elaborate iron or other weighty fittings must mean a corresponding reduction in carrying power.

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Only two cars—the staff and kitchen car—were fitted with tanks. These tanks, six in all, cylindrical, carrying some 1,800 gallons, were placed under the cars, and were easily filled from tanks or taps at the various stations; the water was passed through Berkefeld field filters before use. All water required in the cars used as wards had to be carried from the kitchen car, involving almost continuous labour on the part of the already heavily-worked orderlies. The provision of tanks to each car would be undoubtedly the ideal arrangement (as carried out in the "Princess Christian" train), but here again the ideal must be sacrificed to the practicable; filling tanks on every car is a lengthy process. It took about two hours in the case of the "Princess Christian" train, and is more often than not impossible in a crowded station in war time.

Each car, with the exception of the kitchen and pack-store cars, had a small lavatory, fitted with a hand basin and w.c. of the usual railway type, at either end. During short stoppages in railway stations these were always locked. When the train, as frequently happened, had to remain some hours in station or hospital sidings, buckets with dry earth were placed underneath the w.c. pipes, the station and hospital authorities being responsible for their disposition and removal. A supply of 5 per cent. Izal solution was kept in each lavatory to disinfect the excreta as far as practicable. Bed-pans and urinals were provided for 15 per cent. of the patients, and this provision was always found ample for No. 5 Ambulance Train, which did not run during the early part of the war, and never carried such numbers of helpless sick and wounded as some of the other trains.

A visitor inspecting the train would enter the saloon car first, and from it walk through the kitchen and four ward cars to the pack store, and this is the most convenient order to adopt for a more detailed description of the construction.

Saloon Car.—This was a first-class saloon car of the Cape Government Railway, entered by steps at either end, and communicating with the kitchen car. It contained five compartments, the usual first-class compartments with sliding doors opening on to the corridors, with a lavatory at each end. Two of these compartments at one end, separated by a right-angled passage (fitted up with cupboards as a tiny pantry) from the other three, were occupied by the nursing Sisters. Of the remaining three, two were the rooms of the Medical Officers; the third, next the pantry, formed a little dining room in which four—or, at a pinch, five—persons could have their meals with a fair degree of comfort. The only modifications adopted in this car were the removal of superfluous seats in the Sisters' and Medical Officers' compartments, the provision of racks and hooks for clothes, etc., and the conversion of the right-angled passage between the dining room and Sisters' quarters into a little pantry by means of added shelves. The lavatories, fitted with w.c.'s and basins, were of fair size, and with a little manœuvring and the addition of camp canvas baths could be used as bath rooms.

Kitchen Car.—This car included three separate compartments, extending the whole breadth of the coach without corridors, communicating by doors. The centre compartment, much the largest of the three, constituted

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the very excellent kitchen, fitted with a large German range and boiler, dressers, cupboards, etc.; the range, a very fine one, occupied nearly the whole of one side of the kitchen, and by its weight tilted the car to that side a few inches, giving the car a somewhat lopsided appearance. On the side next the saloon car was a small compartment used as a pharmacy, with shelves and lockers for the medical and surgical equipment, and four fixed wooden bunks for N.C. Officers and batmen. On the other side of the kitchen was a larger room used as a mess room by the orderlies, which was fitted up with six bunks and a table, thus providing altogether sleeping accommodation for 10 N.C. Officers and men.

Ward Cars.—(3), (4), and (5) cars were all of similar construction, so that one description will suffice for all. The original third-class corridor cars had all the interior fittings removed and replaced by two rows of fixed wooden bunks, each row in two tiers; a central passage extended from end to end of the car between the rows. The continuity of the bunks was broken in the centre of the car by two large doors facing each other, large enough to permit of stretchers being carried in, and, with the help of hinged posts in the corner bunks, carried down the centre passage to any particular bunk or bunks. The transference of a patient from stretcher to bunk was easily carried out by gently lifting or rolling in from the stretcher placed beside the bunk. The bed-cots in the "Princess Christian" train were so arranged that they could be lifted out of the train,—a better plan, of course, as patients could then be transferred from the stretchers on the platform—but on the whole the plan adopted on No. 5 Train worked well, and involved no complicated fittings. The lavatory at each end of the car contained a fixed basin as well as w.c. Undoubtedly the ablution arrangements were quite insufficient in view of the fact that patients were sometimes as long as six days on the train; they had to be eked out by serving out hand-basins to each car. As a rule six basins were thus served out, making, with the fixed ones, eight for the 24 occupants of the ward.

Each bunk was composed of headboard, tailboard and sideboard (the other side being formed by the side of the train), and measured 6 feet 3 inches long by 2 feet 9 inches wide; the bottom was formed of tightly stretched canvas; horsehair mattresses, blankets, pillows, sheets, and pillow-slips were provided. The mattresses were provided by the Cape Government Railway; the other articles were drawn, replaced, etc., in the usual way. The sideboard could be removed to facilitate transference of patients from stretchers and *vice versâ*.

(6) ward car was originally the same as the others, except that eight bunks at one end were screened off for Officers by means of draw-curtains. This arrangement was unsatisfactory, except on the rare occasions when all the Officers were lying-down cases; so the four bunks on one side were removed and replaced by windows, a table, and some easy chairs, thus making a very comfortable bed-sitting room for four Officers, and reducing the number carried in the whole car from 24 to 20. In No. 2 Train this ward car was the same as the others, and carried 24.

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(7) car.—The major part of this car was fitted with shelves and lockers, the former for men's kits, the latter for linen, spare blankets, Red Cross stores, etc. The far end of the car was converted into a steward's store, where all wines, spirits and extras were kept under lock and key. A small intermediate passage between these two rooms was used by the guard, and contained three bunks for the conductor and two orderlies, making, with the berths in the kitchen car, sleeping accommodation for 13 N.C. Officers and men.

Each car had a large red cross painted on the outside on a white disc.

Equipment.—The medical and surgical equipment was that of a field hospital,* supplemented as occasion required by other drugs and articles which were always obtained without difficulty from advanced or base depôts of medical stores. All other articles of hospital equipment were drawn and held from the Ordnance—knives, forks, spoons, tin plates and mugs, blankets, etc.

The management and equipment of No. 4 Train were on much the same lines as the above, but its construction differed widely from that of the others, and requires a separate description. No. 4 was fitted out as a hospital train at East London by the Red Cross Society, under the personal supervision of Sir John Furley. The work was put in hand on April 20th, 1900, and the train started on its first journey on June 10th, 1900.

"The train at first consisted of five coaches and a brake van. Later on two additional carriages were provided, making up a total of 114 beds, including six in a separate compartment for Officers. Two small vans were also added for soldiers' kits, pack stores, and guard. A continuous passage ran through the train and each coach had a lavatory. The water for the train was carried underneath the coaches. Folding doors, one each side of every carriage, allowed the sick and wounded to be taken in and out on stretchers. The beds consisted of iron moveable brackets with sheet canvas and hair mattresses and sheets, blankets and coloured counterpanes. As the beds folded up, every facility for airing and cleansing was afforded."†

These beds were arranged in three tiers (a tier too many). Their moveability and capacity for folding up were doubtful advantages, involving frequent repairs and a certain feeling of insecurity for the patients. On the whole the system of fixed wooden bunks is preferable. Tanks under each coach save the train staff much labour, but in war time it is often difficult, sometimes impossible, to fill them all; the process is a very lengthy one, involving delicate shunting work and a considerable length of free line-space, both conditions often unattainable in a crowded station.

No. 4 Train was painted white outside (an undoubted advantage) with red crosses on each coach, like the "Princess Christian."

* Namely, 2 field medical companions, 2 surgical haversacks, 4 field medical panniers, 1 special surgical pannier, 1 field fracture box, and 1 antiseptic case.

† "Report of the Central British Red Cross Committee on Voluntary Organisations in Aid of the Sick and Wounded during the South African War."

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The car for the staff and the kitchen car were, speaking generally, of the same type as the corresponding coaches of the other converted trains.

Personnel.—No. 6 carried only 1 Medical Officer, 1 cook, 1 compounder, and 5 orderlies. Each of the other trains had the following *personnel*:—

Medical Staff	...	1 Major, R.A.M.C., in command.
		1 civil surgeon.
Nursing Staff	...	1 nursing Sister, Army Nursing Service.
		1 „ Army Nursing Reserve.

The numbers of the medical and nursing staff remained unchanged throughout the war.

In the early days of running there were 22 N.C. Officers and men; these, however, had soon to be reduced, owing to the exigencies of the service, to 17.

THE "PRINCESS CHRISTIAN" TRAIN.

On the initiative of H.R.H. Princess Christian the train bearing her name was built in England, at the expense of the Red Cross Society, by the Birmingham Railway Carriage and Wagon Company. For the general design and internal arrangements Sir John Furley and Mr. Fieldhouse (of the Military Equipment Company, Limited) were responsible.

"The train consisted of seven bogie corridor carriages, each about 36 feet in length and 8 feet in width, the passage through the centre being continuous.

"(1) was divided into three compartments for linen and other stores, for two nurses, and for two invalid Officers respectively. The second carriage was also divided into three compartments, namely, for two Medical Officers, a dining room, and a dispensary. (3), (4), (5), and (6) were each constructed to carry 18 invalids and four hospital orderlies. The beds were placed in three tiers . . . and by an arrangement of pulleys in the roof each bed could be raised to the proper level by one man. . . .

"(7) contained the kitchen and pantry, including berths for two cooks and a compartment between for the guard. . . .

"The whole train was light and airy, and the enamelled white ironwork and fittings and the bright draperies produced a very cheerful effect. . . . It was painted white externally from end to end."*

The medical, surgical, and other equipments were on a most extensive but unnecessarily elaborate scale.

Experience showed several defects in the construction and arrangement of this expensive and beautiful train. The position of the linen store was most inconvenient; that most necessary item in any military hospital unit, the pack store for men's kits, was forgotten (a Cape railway van, not communicating directly with the rest of the train, had to be added for this purpose); three tiers of beds are one tier too many; the numbers

* Report of British Red Cross Committee.

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carried—two Officers and 72 men—were limited compared with the converted trains. Lastly, the otherwise excellent system of tanks to each carriage necessitated great inconvenience and delay in stations and sidings.

On the whole, the arrangement of the bunks and general construction adopted in the converted trains was preferable; with the addition of some fixed basins, surmounted by a small tank capable of being filled by hand, to each ward car, the type of converted train represented by No. 5 would prove the most generally useful in future campaigns.

The *personnel* of this train normally consisted of two Medical Officers, two nursing Sisters, cook, compounder, and 12 orderlies.

IMPROVISED HOSPITAL TRAINS.

Except that the staff was put on for the journey, the work of these trains was much on the same lines as in the hospital trains proper.

ORDINARY TRAINS.

A very large number of convalescents were sent to the base by this means, notably during the enteric fever epidemic at Bloemfontein. At the time of the Bloemfontein epidemic, the line from there to Cape Town was clear so that trains could run through without stopping at night; hence the want of cooking arrangements on the train was not felt, hot meals could be served to patients at certain fixed stations, and the system, on the whole, worked well. When, however, a line is infested by the enemy, so that train stoppages become irregular and for indefinite times, hospital train units must of necessity be self-supporting.

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LAND DEFENCE OF SEACOAST FORTIFICATIONS.

Extracts from an Article by CAPTAIN E. H. SCHULZ, *Corps of Engineers, U.S. Army, in the* JOURNAL OF THE MILITARY SERVICE INSTITUTION, U.S.A. *January—February*, 1905.

It is only within recent years that the land defence of our seacoast fortifications has received extended study. Our older fortifications made provision against land attack, but since the installation of modern armament, in concrete constructions, the matter has been held in abeyance. This is partly due to the fact that our resources and energies have been used in providing the armament itself, which is of recent growth, beginning practically in 1890. During the short space of time that has elapsed, upwards of 800 seacoast guns and mortars have been emplaced.

Up to the present time projects for permanent seacoast defences have been adopted for thirty-one localities in the United States. In addition to these, the defence of the Great Lakes and the St. Lawrence River is under consideration. Twenty-five of the principal harbours of the United States have a sufficient number of heavy guns and mortars mounted to permit an effective defence against naval attack, and during the past four years considerable progress has been made in the installation of an adequate rapid-fire armament, now the matter of first importance.

The existing projects for seacoast defences comprise 364 heavy guns of 8-inch, 10-inch and 12-inch calibres, 1,296 rapid-fire guns from 2·24-inch to 6-inch, and 524 mortars.

Projects for the defences of San Juan, Porto Rico; Pearl Harbour and Honolulu Harbour, Hawaii; San Luis d'Apra, Guam, Manila Bay, Subig Bay, have been approved by the Secretary of War. In addition projects for Cebu and Iloilo, P.I., have been submitted, and others for the defence of our naval coaling stations are under consideration.

It is thus seen that the armament already provided is of immense value, and forms practically a complete defence of our seaports and adjacent cities. The loss in prestige, not to mention the actual loss of armament, would therefore emphasize the great importance of adequate land defence. When we add to the above the auxiliaries of defence, such as range-finder stations, searchlights and torpedoes, the folly of not thoroughly defending them from land attack is evident.

At the present time sixty-six fire and battery commander stations are in use by the artillery, and seventy-seven are under construction. This is but a beginning of our range-finder system. The torpedo defence is in charge of the artillery arm, and its *matériel*, including loading-rooms,

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storehouses, range stations, presents an aggregate value, when fully equipped, of over three million dollars.

The permanent defences have now reached that degree of completion where the rear defence becomes of paramount importance, and this has been recognised by the War Department. Projects for land defence have already been considered for the most important harbours.

The seacoast fort or battery has a double problem to solve:—

(*a*). It must fight the enemy's vessels, destroying them if possible.

(*b*). It must be defended from land attack in the rear, or from landing parties attacking from any direction.

The discussion of an engagement with the enemy on the water may be omitted, as all our emplacements are designed to give the maximum efficiency in such an engagement. Our heavy guns can, however, fire only to the front, with a possible fire of the flank guns of 20° behind the line of gun centres, while to the rear they have no fire.

The rapid-fire guns (in which we may include the 6-inch, 5-inch, 4 7-inch and 3-inch in permanent emplacements) have, in some special forms of emplacements, fire to the rear; but generally, with the exception of the 3-inch, we may consider them as limited to front and flank fire. All the rapid-fire guns can and should be used in repelling land attack in the directions of their fields of fire. The guns of greater calibre cannot be so considered, as their rate of fire, speed of laying, etc., would preclude their efficient use. For such an attack the rapid-fire guns would be more effective and should be provided. It may be stated that, in addition to the above rapid-fire guns, the 6-pr. (2·24-inch) is also considered a gun of the permanent defence. This gun is now provided with a rampart mount; it is, however, the intention to give it a permanent pedestal mount.

In considering the nature and extent of the land attack, several important considerations must be taken into account:—1st. The value of the harbour or city and of the particular fortification in its defence. 2nd. The character of the enemy, and his distance from base of supplies. 3rd. The characteristics of the coast, as to feasibility of landing and intermediate territory to be traversed.

The following may be considered as self-evident:—1st. The enemy will not hazard to force the entrance to our harbours in daylight in the face of our present strong fortifications. 2nd. He will not engage our batteries for the purposes of combat; if he engages them at all, it will be mainly for purposes of reconnaissance. 3rd. He will not engage the batteries at any time except when the odds are greatly in his favour. 4th. His first object will be to capture the batteries and injure the armament beyond use, or else employ them in attacking other batteries, and this will be attempted entirely by land attack.

We thus see that the importance of land defence is as great as the necessity for the permanent defences themselves.

Let us now ascertain the character of a land attack, involving as it does the number of troops and their equipment. The complement of a first-class battleship is about 700, of a first-class cruiser the same, and of the minor vessels proportionately less. Considering a European fleet,

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manœuvring in the vicinity of one of our harbours, consisting of 2 battle-ships, 3 first-class cruisers and about 8 to 12 vessels of minor size, the total complement would be about 6,000 men; of this number half might be available for a sudden dash against the batteries. The enemy, thus numbering about 3,000 men, would proceed, in light-draft torpedo-boats, launches or ship's boats, under cover of darkness or fog and through unfrequented channels, carefully picking their way over suspected mine-fields, and make a landing in the rear of the works or at some distance on the flanks. In any case, the objective would be to land the greatest number of troops in the safest and most expeditious manner and as close to the works as possible, and then proceed over land to attack and capture the work. The attacking troops would be provided with their own service rifles; and in addition would probably land machine, field and rapid-fire guns up to 3-inch calibre, and in exceptional places 5-inch or other siege guns. The facilities for landing must in the latter case be exceptionally good.

Having made the landing, attack or capture would be certain unless our batteries were protected by proper land defence; for it cannot be assumed that the artillery *personnel* of the battery will be able to cope with an attack in the rear as well as continue a fight with the enemy on the water, especially if no provision for immediate rear defence has been made.

The protection required against the modern Springfield rifle and similar types is as follows:—Sand $2\frac{1}{2}$ feet, earth $3\frac{3}{4}$ feet, soft wood 5 feet, hard wood $2\frac{1}{2}$ feet, wrought iron $\frac{5}{8}$ inch, hardened steel $\frac{5}{16}$ inch. The following are approximate penetrations at muzzle:—U.S. rifle, calibre ·30, 3 feet earth, $2\frac{1}{2}$ feet sand. U.S. field gun, 3-inch, model 1898, 4·5 inch steel, 13 feet sand. U.S. siege gun, 5 inch, model 1898, 6·2 inch steel, 18 feet sand. For calibres over one inch, the relative protections afforded may be taken as follows:—1 inch of W.I. = $\frac{5}{8}$ inches of steel = 30 ft. of sand = 36 ft. of earth.

It will be seen that for absolute penetration unwarranted thickness would be required against field and siege guns. As, however, these guns are seldom used for direct penetration but rather for their shell and shrapnel fire, a protection of 6 feet of earth is considered ample; consequently, in designing fieldworks 3 feet of earth would be sufficient against small-arm fire, and 6 feet against all others.

The effective range of the service rifle may be taken at 1 mile, of the field and rapid-fire guns at 3 miles, and of the siege guns and howitzers at about 4 miles. In planning our fieldworks, then, they should be at such distances as to prevent the enemy from occupying positions within the above ranges of our permanent fortifications.

As a land attack would hardly be undertaken without field and rapid-fire guns, we may consider the zone of danger to be generally taken as 3 miles; and for important harbours, or where landing of siege guns is especially favourable, a radius of 4 miles.

The weight of the U.S. Navy field piece, 3-inch, with carriage, etc., is 1,830 pounds; of the U.S. 5-inch siege gun, without carriage, about 3,630 pounds; of the British 5-inch howitzer, carriage and limber, 5,040 pounds.

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We thus see that the heaviest single weights to be brought ashore would not exceed about 3,600 lbs.; an operation which, while almost impossible in certain localities and weather conditions, is yet one which an enterprising enemy would readily attempt under favourable circumstances.

It is manifest that the regular coast artillery will be insufficient to properly care for the land defence. Their time and labour will be taken up entirely in looking after the naval attack. In an emergency they must also take part in the immediate defence against attack from the rear. Our main reliance for the preliminary defence must therefore be placed on the organised militia of the various States, who are fully prepared to act in such an emergency.

We must make such a disposition as will effectively prevent the advanced line from being penetrated or driven back. To this end salient positions of the defensive line must be occupied, including important bridges, roads and heights. These positions should be occupied by field-works of sufficient size and strength to withstand the probable attack; and should be such as to cover to the best advantage the intervening ground, as well as to command the approach.

Assuming that the nature of the terrain would allow and require the use of light artillery and cavalry, as well as of infantry and engineers, a total of 1,000 men would be divided approximately as follows :—

7 companies of infantry, 1 troop of cavalry, 1 light battery or company of foot artillery, 1 company of engineers.	Or troops acting as such.

Four companies of infantry would be encamped near the entrenched positions ready for immediate occupation. They would have scouts patrolling the line between these positions, ready to communicate information at a moment's notice. The cavalry and light artillery would be encamped in rear of the line. There should be cavalry outposts well in advance of the main line on the coast and along important communications. Where light artillery is not needed, foot artillery may be substituted for manning the various field guns. The remaining infantry should be encamped near the permanent works for defence of the shore front, flanks and immediate rear defence. The engineers would be encamped near the reserve infantry and utilized in repairing roads, bridges, obstructions and field defences and on demolitions.

The general character of the entrenched positions may now be considered. A closed work would in nearly all cases be undesirable, since rapid ingress and egress are important considerations. The parapet should be 4 to 6 feet thick, arranged for infantry fire and provided with suitable platforms for the necessary field guns. The trenches should be located on important sites, but well concealed. The intervals between positions should be covered by infantry lines where approach is possible. These lines, as well as the trenches in the earlier stages, should consist of shallow lying-down trenches, deepened to kneeling or standing trenches where time will permit and where drainage is practicable.

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A retired line should be constructed upon similar principles. Parapets should also be thrown up between emplacements along the sea front, and also directly in rear and surrounding all the fortifications. It will be noted that no regular redoubts are provided for.

The results thus far of the Russo-Japanese war show that concealment of positions is only second to their proper location. In the battle of Wa-feng-gu on June 16, 1904, the Japanese field artillery made frightful carnage among the Russians, due to a great extent to lack of concealment on the part of the latter. The Japanese field guns numbered 108 and the Russian 64; the range was 3,800 yards, about 2 miles; and within fifteen minutes after the opening of the combat, the Russian guns were completely silenced. From 10,000 to 15,000 shells were thrown by the Japanese and all by the indirect method, firing from concealed positions. In the Boer war the Boers made use of deep narrow trenches, with inconspicuous parapets.

Vertical cover should also be provided, especially for men not actually engaged; and this can best be obtained, where the terrain will allow, by constructing bombproofs under the parapets.

The works should not only allow of good passive defence, but also for an active offence, and to this end the greatest possible mobility must be provided. Machine guns form a most invaluable aid to the infantry against close attack. The artillery should preferably be in independent positions so as not to draw fire on the infantry. The guns should be well separated, and platforms constructed in all good positions, with connecting communications so that the field guns can be readily moved. Even the heavier siege artillery should not be considered strictly fixed, as to some extent these pieces can be moved when desired, though of course more slowly.

The trenches should generally not be placed directly on the brow of a commanding position, but a short distance below; this conceals the position and prevents a sky-line profile. This entire subject is thoroughly discussed and exemplified in *Principles of Land Defence*, by Capt. H. F. Thuillier, R.E.

All the obstacles known to the military engineer should be utilized where practicable; but in all cases of emergency, and especially where other means are limited, a barbed wire entanglement would be at once the simplest, cheapest and most effective obstacle that can be provided. The lines of wire should be located where the terrain will allow, at distances of 50 yards in front of all redoubts, fieldworks and trenches, and again at further distances of 200 to 400 yards. The lines should be as high as can be made consistent with concealment and rapidity of construction, and should not be less than three tiers deep. The intervals between the stakes of the wire obstacles should be covered with small pointed stakes or any other additional obstacles that may be provided.

The number of field guns that would be required in preliminary defence, as above outlined, can only be generally given; allowing four machine guns and four 1-pounder automatic guns to each position (of four), and six field guns, two machine and two 1-pounders for the general defence, the total number would be about forty-two guns of light field type and

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smaller calibres. Siege guns and howitzers should also be added where required.

The labour involved in constructing the fieldworks and trenches would be performed by the troops, and the cost would therefore be only for the implements used. As the preliminary defences become completed they should be made of a more permanent character, and additional material obtained to facilitate both defence and offence. Under this head would come prominently the use of searchlights, including complete power and transportation equipment. Plotting rooms, telephones, depôts, etc., should also be supplied.

The above general discussion provides for an immediate land defence only, required under great emergency and for defence against sudden attempts to capture the works. Where the attack is to be made by regular siege, or where a large city, depôt or other strategic position is to be defended, the main line must be considerably advanced; and the works placed at intervals should be of a more permanent character, but nevertheless give thorough concealment and mobility.

The importance of having some general plan, well digested and laid out, for this preliminary defence of each harbour is self-evident. The location of the lines of defence and of the works, the nature and number of obstacles and their position, the proper camping places, should all be thoroughly considered and placed on record so that work could be begun almost immediately when required. The inner line of defence, which practically surrounds the fortifications at close range, should be laid out during peace and constructed before the advent of war. It should be a part of the permanent defence of the fortress, and, if funds are available, constructed at the same time. The Russo-Japanese War, especially the attack and siege of Port Arthur, leaves no room for doubt that fortifications in the future will be attacked not from the water but entirely by land; and that we can begin none too soon in establishing a complete system of land defence for each of our fortified positions in this country as well as in our possessions. A preliminary defence as above outlined therefore needs a supplemental land defence of permanent value, which should likewise be prepared and completed as far as possible before the outbreak of war.

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REVIEWS.

DIE FESTUNG IN DEN KRIEGEN NAPOLEONS UND DER NEUZEIT.

Herausgegeben vom Grossen Generalstabe.—(Mittler: Berlin. 1905).

It is to be hoped that this work, issued by the historical section of the German General Staff, will find an English translator, for it is a book that all officers would do well to read. It concerns itself little with technical details; its aim is to show what was the influence of fortresses in the chief campaigns of the 19th century, and what lessons for the future may be drawn from the experience of the past. In 335 pages, and with the help of an atlas of plans, it contrives to give the reader a clear account of the operations chosen, and to bring out the bearing of them. We cannot do better than give a short summary of the line of argument.

The wars of the 17th and 18th centuries were mainly wars for the extension of frontiers. The capture of frontier fortresses was the principal object, and to this the field operations were subordinate. Siege-work was reduced to a system, and like fortification it was relegated to experts, who practically dominated the course of a campaign. Frederick the Great was the first to break through this tradition, to regard fortresses as mere means to an end, and to impose terms on his enemy by victories in the field. Napoleon followed his example, and his ampler resources enabled him to better it. He showed the fullest appreciation of the value of fortified posts and places, but he always looked beyond them.

Mantua in 1796 and Genoa in 1800 are the first two instances chosen, and they present a striking contrast. Napoleon could not afford to pass Mantua by, he was ill-provided for a siege, and he had not men enough for a siege army and a covering army. He was obliged to abandon the investment and sacrifice his siege train when the first relieving army, under Wurmser, drew near. Yet the fortress proved a snare to its possessors. The Austrians wore themselves out, and crippled their operations in Germany, by successive efforts to relieve it, and lost it in the end. Genoa, like Mantua, was starved into surrender, but not till it had served its purpose. Instead of coming to its relief, Napoleon placed himself on the Austrian line of communication, and the victory of Marengo won back all North Italy as far as the Mincio.

In Prussia the stress laid on well-drilled battalions and field evolutions had caused neglect of fortresses; and in 1806 the victory of Jena made Napoleon master of all the country west of the Vistula before the Russians

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could come up. The defence of Dantzig in 1807, though by no means a model, served to show how important a part might be played by a fortress which was accessible from the sea and threatened the enemy's communications.

This was repeatedly illustrated during the war in the Peninsula; and that war also furnishes instructive examples of accelerated sieges, where time is of the first importance. Ciudad Rodrigo was taken by Wellington in 11 days, Badajoz in 20 days; while the French had spent nearly six weeks in taking them. Methodical as he was in field operations, Wellington broke loose from the Vauban method in these sieges, and set a new example. His procedure was defective in details, but "it is not the precise mode of execution which is a model for us; it is the spirit of unhesitating energy which animated it, and the sound estimate of the influences which the general military situation should exercise on the method of attack."

In 1805, in 1809, and again in 1813, North Italy was a secondary theatre of war, and it was Napoleon's plan to act on the defensive there, and to gain time. The fortresses of the Venetian quadrilateral served him well for this purpose, and his elaborate instructions to his stepson, Eugène Beauharnais, deserve study. Those fortresses served the Austrians equally well in 1848 and 1866, when they had to hold their ground against superior numbers. In the latter year, Cialdini proposed to turn the Quadrilateral by crossing the Po lower down, and Moltke agreed with him; but great difficulties and risk would have been incurred by such a course.

The principles inculcated by Napoleon for the defence of North Italy were applied by him in North Germany in 1813. But the field was wider, and the fortresses were ill-fitted for an active defence, so that they exerted less influence on the operations. The very large numbers at the disposal of the Allies made it possible to mask these places without dangerously weakening the main armies; and when Napoleon was driven back across the Rhine, after Leipzig, he left behind him 150,000 good troops in German garrisons, an irreparable loss to him. Not much less was the number of men employed to garrison the fortresses of the French frontier; but these were mostly new levies or men unfit for the field, and the writer holds that Napoleon was justified in not abandoning any of those places. When the Allies crossed the Rhine in 1814, the Austrians had a good deal of hesitation about passing the French fortresses, and left large forces to watch them. The Prussians were bolder, and it must be recognized that it was less important then than it is now to guard the communications of an army against occasional interruption. The want of siege guns prevented the Allies from dealing with these places after Wellington's method.

The Turkish fortresses in Bulgaria—Schumla, Rustchuk, Silistria and Varna—formed a quadrilateral which, though less effective than that of Venetia, has played an important part in several wars. It delayed the advance of the Russians in 1828, and again in 1853. In 1877 they decided to march round it; but the improvised fortress of Plevna enabled the Turks to threaten them on both flanks, and siege operations, which they

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had hoped to avoid, became a necessity. They had undertaken the war with inadequate forces, their position was at one time very critical, and they were only saved by the incapacity of the Turkish generals.

The siege of Sebastopol (1854–5) presents a very different case. It was for its own sake, and for the sake of the fleet which it sheltered, that Sebastopol was attacked and defended, not as a step to ulterior operations. Russian pride became involved, and the so-called siege was in fact a series of encounters between the Russian and Allied armies under conditions favourable to the latter. There was a want of concert between the garrison and the Russian troops outside, which enabled the Allies to win in the end, in spite of many mistakes.

Two examples are taken from the American Civil War: Vicksburg and Richmond. Both made a stout resistance with improvised works; but it would be a mistake to conclude from these instances, or from Plevna and Sebastopol, that there is no need in these days for permanent works. High-angle fire was little used, and for protection against such fire deliberate construction is important. At Vicksburg the mistake was made of sacrificing an army for the defence of a position, which had lost its value as soon as it was shown that it did not really close the Mississippi.

About one-third of the volume is devoted to the Franco-German War of 1870–1. "Metz," says the writer, "was the grave of the French army of the Rhine, not because it is always hazardous for a field army to keep in touch with a fortress, but because the French leader was not equal to the requirements of the situation, and especially lacked the activity and decision of character which are needed for operating under such conditions against an enemy superior in numbers." Instead of allowing himself to be shut up in Metz, he should have used the fortress as a pivot, as Radetzky used Verona. Even when he was shut up there, he might have broken out towards the south-east; and if only part of his army had got clear away it would have formed a most valuable nucleus for the new levies. As it was, the maintenance of the blockade put a very severe strain on the German resources, and came to an end only just in time. This might have been escaped if heavy howitzers had been available to silence the forts immediately after the battle of Gravelotte.

Similarly in dealing with Paris and with the smaller fortresses, the Germans felt the want of siege guns at the outset. Their field guns were quite ineffectual, their transport was ill-organised, and they were obliged to trust to starvation to bring about the surrender of Paris. The food supply was underestimated, and the four months during which it held out gave the country a breathing time which amply justified the fortification of the capital.

The general conclusions of the writer are that railways have given fortresses a new value, whether as mere barrier-places on important lines or as intrenched camps affording prepared battlefields. Experience shows that, instead of going round fortresses and leaving corps to watch them, it is much better for the invader to try to capture them expeditiously. Wellington's example in the Peninsula, and the storming of Kars by a night attack in 1877, encourage the belief that sieges may be accelerated; but heavy artillery and abundant ammunition must be at hand for this

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purpose. Fortress warfare must not be regarded in future as a distinct thing from field warfare, and must not be handed over to technical corps, but must be directed by the headquarter staff; and there must be a readiness to incur heavy loss when the importance of gaining time warrants it.

It is for this reason, as is explained in the preface, that the subject has been dealt with in this series of monographs issued by the German General Staff; from the conviction that all branches of the army should take more account of fortresses, and should recognise that sieges are not something quite special, but only one of the many shapes of war. No allusion is made to the war now in progress, but from the tone of this volume it can hardly be doubted that the German Staff does not share the strange views of its brilliant eulogist in *The Times* about the "entanglement of Port Arthur," but would range itself with Capt. Mahan.

E. M. LLOYD.

PROBLEMS IN MANŒUVRE TACTICS.

By MAJOR J. H. V. CROWE, R.A., *p.s.c.*, Chief Instructor, R.M. Academy. AFTER THE GERMAN OF MAJOR HOPPENSTEDT.—(Smith, Elder & Co. Price 6s.).

Major Crowe, R.A., publishes an adapted translation of one of those practical German military works which are so conspicuous by their absence in the British service.

Until the translation, some 8 years ago, of Griepenkerl's *Letters on Applied Tactics*, almost the only means that the English student of Minor Tactics had of practising for himself and developing the principles he learnt from textbooks was to procure old promotion exam. papers, with their sketchy maps, and take his solutions to a crammer for criticism.

The 24 schemes which Griepenkerl worked out with such artistic care and logic, and the excellent maps referring to them, supplied an acute want; and many an English major would have been in a sad plight when preparing for "Tactical fitness," had not our German friend come to his aid just about the time that the test was established. At the same time the "Letters" had a stolid, argumentative, "German" flavour about them, which enforced careful and deliberate consideration and much studious "application."

Major Hoppenstedt now presents 224 problems, in 80 pages, followed by their solutions in 80 pages more. The title "Manœuvre Tactics" prepares us for a much more "Field Training" kind of study and for problems of a *solvitur ambulando* nature. The exercises are chiefly on situations, developments and collisions which would occur during

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manœuvres, rather than the preparation of elaborate schemes before contact with the enemy. There is a breezy, cut-and-thrust emergency air about them which animates them with a vivid realism and renders them interesting as well as instructive.

The solutions to each problem are only sketchy appreciations to guide the student and stimulate him to observe the tactical principles which the exercise is meant to exemplify; the details are left to be filled in, perhaps differently by each solver, according to his military character.

The author says that the book "is designed to assist officers in self-instruction in Manœuvre Tactics and in preparing for examinations, to provide suggestions in the drawing up of schemes for manœuvres, field days, staff rides and war games, and to familiarise officers with the action of the three Arms when working in co-operation"; and it fully satisfies these aims.

It may be well recommended to the notice of any young officer, who is no longer too proud to acknowledge how little he really knows of manœuvre tactics, and what a sorry figure he would cut if he were suddenly confronted by any one of the situations discussed, especially if there were shells and bullets coming from the enemy's weapons. But he must work out the problems conscientiously himself before he turns to the crib at the end of the book. If, on reading Major Hoppenstedt's solution, he cannot see his mistakes, he can argue the matter out with some of the innumerable "instructors" which the reformed British Army now possesses in the persons of all its officers. Then, furnished by Griepenkerl with deliberate fire and by Hoppenstedt with rapid fire, the aspirant to promotion should be able to defeat any Tactical Examination Board with honours.

The problems are all located near Metz; the ground ought therefore to be familiar to most officers who have dipped into modern military history. There are three maps with the book:—(I.) a hill-shaded map on a scale of 1·58 miles to 1 inch for the general work, (II.) a section of the local General Staff map, 2·53 inches to a mile with 20-ft. contours, on which the mere detailed problems are to be worked out, and (III.) a skeleton map, scale 4·73 miles to 1 inch, to follow out the strategical situations of the larger problems.

Map (I.) is a very inferior production, enough to make the hair stand on the heads of our spoilt generals and staffs who are accustomed to our equivalent, 2 miles to 1 inch, beautiful Ordnance Survey map. The names are most difficult to read, while the black hill shading, which covers the paper without giving any idea of the value of the hill features, and the heavy representation of woods and forests, almost obliterate the detail. However, the student who wishes to preserve his eyesight can of course easily procure and use the maps belonging to the German Official History of the 1870 War, which cover the same ground. It is not perhaps a bad exercise for officers to get accustomed to such inferior maps, which they would have to put up with on active service even on the Continent, and which, scale for scale, cannot compare with ours for clearness and military utility, though they may be superior as expensive works of art.

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However, this one defect of Map (I.) detracts only slightly from the value of the work, and the Service owes a debt of gratitude to Major Crowe for bringing the book within reach of the British officer. He has converted the units of the German organization into their English equivalents, which conveniently "naturalizes" the text; and the scales of the maps are in miles and yards. Some day, when the reformed War Office can afford a professional library for the officers' mess of each unit of the reformed Army, this is one of the books that should certainly find a place on its shelves.

G. H. SIM.

REPORT OF THE DEPARTMENTAL COMMITTEE ON INDUSTRIAL ALCOHOL.

In August last a Committee was appointed to inquire into the existing facilities for the use of alcohol without payment of duty in arts and manufactures and for the production of motive power; and to determine the conditions of greatest freedom that could be accorded to its use for those purposes, consistently with adequate safety to the revenue derived from spirit as an article of human consumption. Their report has now been presented to both Houses of Parliament.

It had been contended that spirit for industrial purposes was excessive in price owing to the cost of excise supervision, and that in many cases it was rendered unsuitable for use by the process of denaturing.

The Committee examined a number of witnesses, representative of the industries in which alcohol is employed; obtained information as to the regulations in force, in this and other countries, governing the use of spirit for industrial purposes, and as to the quantities of spirit so used; and sent a sub-committee to Germany to inquire on the spot as to the system and regulations established there.

Hitherto two kinds of methylated spirit have been available for use duty free:—(*a*) ordinary methylated spirit, containing 10 per cent. of wood naphtha, which can only be purchased in large quantities from a methylator; (*b*) mineralised methylated spirit, which is the same as the preceding with an addition of ·375 per cent. of mineral naphtha (petroleum) and can be obtained retail. By the Finance Act of 1902 special processes of denaturing, appropriate to particular industries, could be employed, subject to the approval of the Board of Inland Revenue.

The Report points out that the chief hindrance to the use of spirit for industrial purposes is its cost. The wood naphtha used for denaturing costs more than double the price of the equivalent quantity of spirit, and in some cases makes it less efficient for use; but these objections have to a certain extent been met by the Act of 1902, the provisions of which do not appear to have been well known to manufacturers.

The cost of denaturing is not however nearly such an important factor

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in the price of the spirit as the conditions and restraints imposed on its manufacture for the protection of the revenue; the enhancement in price due to this latter cause is estimated at 3d. per proof gallon, or an increase of about 50 per cent. on the cost that would otherwise prevail. In order to counterbalance this a "surtax" of at least 3d. per proof gallon is levied on all imported spirit.

The final result upon the price of industrial spirit of all the measures taken to protect the revenue may be stated as follows:—Spirit used in manufacture is commonly about 64 over proof (about 93 per cent. on the continental standard of pure alcohol), and is plain spirit. Therefore, the price of a bulk gallon of the spirit is about 5d. more than it would have been but for the excise restrictions. The cost of methylating may be put at between 3d. and 4d. per bulk gallon; so that of the price eventually paid by the manufacturer, which at present may be taken at from 20d. to 22d per bulk gallon for large quantities at wholesale price, about 8½d. is attributable to precautions on behalf of the revenue.

The Committee took evidence as to the use of alcohol for the production of the following:—Coal tar colours, smokeless powders, pharmaceutical products,—fine chemicals, ether, artificial silk, lacquers and varnishes.

As regards the use of alcohol as a fuel for motor vehicles the Report is rather disappointing. It is pointed out that it is not used in this country at present, nor to any great extent in France and Germany, in spite of the fact that both these countries are desirous of encouraging the use of a material that is indigenous in preference to one like petrol that has to be imported; and further that spirit presents certain special difficulties which require to be overcome, the principal being the behaviour of alcohol in very cold weather, and the tendency of the acids generated by its combustion to cause corrosion of the metal surfaces with which they come in contact. Consequently any question of the use of spirit for motor vehicles is one of price; and as at present the price of petrol is about half the price of methylated spirit, close investigation of the matter may be delayed until such time as there may be a sufficient approximation between the prices of petrol and spirit to create a practical alternative choice between the two.

The Committee came to the following general conclusions:—

(1). That where spirit is used for general purposes such as heating and lighting, the present mineralised methylated spirit is perfectly satisfactory in respect of character. In respect of price the cost is enhanced by some 40 per cent. by reason of the measures necessary for the protection of the revenue; to counteract this would be merely to relieve the whole community of a burden in one direction by putting upon it an equivalent burden in another. The regulations in regard to its distribution might, however, be appreciably relaxed.

(2). That where spirit is used for industrial purposes, the Finance Act of 1902 provides adequate and satisfactory machinery for securing that the spirit may be used in a condition suitable to each particular purpose.

(3). That something more is required to place spirit used as an instrument or a material of manufacture on a footing satisfactory in the matter of cost.

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The several recommendations may be summarised as follows:—

(1). That an allowance be granted to all industrial spirit, whether of British or foreign origin, at the rate from time to time prevailing for the allowance to British plain spirits on export.

(2). That imported methylic alcohol be relieved from the obligation to pay the surtax, and that methylic alcohol be accorded favourable treatment in the matter of denaturing.

(3). That ordinary methylated spirit should contain only 5 per cent. of wood naphtha, instead of 10 per cent.

(4). That no charge should be made on manufacturers for the regular attendance of excise officers to supervise denaturing operations.

(5). That where spirit is allowed to be denatured with special agents, such agents should be subject to official test and approval; and that accounts be kept in detail of the manufacture and use of such spirit.

(6). That the regulations governing the sale by retail of mineralised methylated spirit should be made less stringent and more elastic.

As regards the use of spirit as a fuel for motors, the following remarks from *The Standard* of 6th May are of interest.

"The Report of the recent Departmental Committee on Industrial Alcohol, appointed by the Chancellor of the Exchequer, has not given satisfaction to the motor trade; and the Society of Motor Manufacturers and Traders, being greatly impressed with the possibilities of alcohol fuel, intends to use all means possible to draw attention to the important bearing it has on the future of the motor industry. The Society points out that at present the demand for petrol in this country is under ten million gallons a year. America already consumes all its own supply, and motorists in this country are dependent chiefly on the oil wells of Roumania and the East Indies. The whole production is under foreign control, and this constitutes a grave danger at all times; whilst in case of war, petrol would doubtless be considered as contraband, and would become simply unobtainable. Moreover, with the increasing use of motor omnibuses and vans, the supply is likely soon to be unequal to the demand. London alone has some 5,000 omnibuses; and on the calculation that these, when mechanically propelled, will run, say, 100 miles a day each for 300 days in the year, 150,000,000 miles will be covered, which (at an average of five miles to the gallon) means a consumption of 30,000,000 gallons annually on this head alone. Besides this, other cities will have their motor services, and vans and heavy vehicles will increase the demand—to say nothing of the larger number of pleasure cars."

J. D. MONRO.

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THE TIMES' HISTORY OF THE WAR IN S. AFRICA.

VOL. III.

The third volume of Mr. Amery's *Times' History of the S.A. War* is distinctly an improvement on Vol. II. The delay in producing it is probably accountable for this; full advantage seems to have been taken of the criticisms on the second volume and of the additional information that has become available, and the general tone of the comments follows that of the German official studies. The style of writing is pleasant and the work is not overburdened with detail, so that it may appeal to the civilian reader as well as to the soldier student. One great charm of the book is the clear printing on non-glazed paper, and its extreme lightness in spite of its bulky 600 pages enables it to be read in comfort.

There cannot be much said in favour of the principle of interspersing portraits, however artistic, in a work of this class; and the editing in this matter shews want of care, as we find opposite p. 528 the portrait of Major-General Sir Reginald Hart, V.C., K.C.B., substituted for that of Major-General A. Fitzroy Hart, C.B. The maps are very clearly printed, though sometimes there is a tendency to overcrowd and confuse them in the attempt to shew too many different phases and situations of the operations. Those that have hill features shewn by contours are far superior to those where "form lines" are used, these latter being indefinite and often misleading as to relative importance of heights. Where contours are not available it would be preferable to adopt some kind of broken hill-shading lines.

The history seems more accurate and reliable than any yet published, and the controversial matters are treated with less acrimony and partisanship than has hitherto been the case.

The "Crisis at Home" after the reverses of Black Week in December, 1899, is dealt with in a calm and critical spirit. In the publications rushed into print during and immediately after the war its gloom was intensified by the exaggerated accounts of neurotic civilian war correspondents; the inefficiency of officers and soldiers was the popular cry, while the spasmodic patriotic efforts of the English people were unduly exalted by the blatant blare of the illustrated and other newspapers. Mr. Amery recounts in a few pages how the British military organization was practically bankrupt when by the middle of December some 85,000 men had been despatched; for though the calling up of the whole of the 1st Class Reserve on December 17th left nominally 100,000 Regulars still in the country, 40,000 of them were useless from extreme youth or deficient physique and the remainder were an uniformed mob without organization or equipment, officers or staffs.

In the Government party politics produced paralysis. Ministers thought chiefly of defending themselves against attacks of the opposition and the press. Salisbury's cynicism and Balfour's complacency were not likely to guide or inspire the nation. Of the opposition a small section were prepared to support the Government; a portion, including the Irish Nationalists, denounced the war or abetted the enemy; while the bulk under Campbell-Bannerman wobbled flabbily hither and thither in their

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anxiety to share the credit for the patriotism of the one wing, without foregoing any political capital that might be made by the methods of the other.

Finally in its helplessness the Government accepted voluntary assistance, but in such directions as would give them least trouble in the way of organization. The Imperial Yeomanry Committee, working independently, forming in fact a sort of small War Office of its own, produced in all about 10,500 men. The 1,740 men that went out with the C.I.V. was not a very great result to shew for the patriotic energies of a city of five millions. The fault lay not in any real want of patriotism but in the lack of military training in all but an insignificant portion of the whole, in the absence of the conception of the duty of personal service, and in the passive obstruction of the authorities, in other words in the inherent defects of our national organization. In addition to the 6,209 who joined with the Yeomanry and C.I.V., 16,500 Volunteers went out in the Service Companies and some 1,500 on other services, or about 26,000 in all in the course of the war.

Amid the excitement of raising the new forces the 45,000 men of the Militia who volunteered and were despatched attracted comparatively little notice.

As a general result of the enthusiasm in our population of 40 millions, one man in five of the Militia, one in fifteen of the Volunteers, and about one man in a thousand of the untrained and unorganized bulk of the male population of fighting age came forward in this emergency. The lesson is that the voluntary reserve which we have to rely on for great Imperial emergencies will vary directly with the numerical strength and degree of training of the National Defence force in this country.

A dispassionate review of the assistance accepted from "the Colonies and the Empire" shews that the voluntary patriotism of the Empire outside the United Kingdom and South African Colonies contributed over 11,000 men to the Field Force during the most critical months, and over 30,000 in the whole course of the war. In proportion to population New Zealand, the most democratic Colony, stands first with 6,434 out of a population of 772,719. On the same basis Australia would have had to send 30,984, Canada 44,152 and the United Kingdom 340,284; Australia actually provided 16,632, Canada 8,372. Besides these Ceylon sent 125, and India 250. India also spared 7,794 of her white troops, besides contributing more than 7,000 miscellaneous native non-combatants, who were of the greatest service, and 6,761 horses. Considerable sums of money were also provided by the Colonies and Empire, and doubtless the help in men would have reached a far higher figure had the Imperial Government thought fit to accept the offers made. Regarded not from the point of view of efficiency but simply as an index of national sentiment it was a wonderful result; and it is on sentiment that all political organization ultimately rests and of sentiment that it is composed. The war has shewn not what the Empire can do but what an Empire we can make if we but choose. It has tested our material and foundations and the task now before us is to build.

A very important introduction to the intelligent study of the campaign from Black Week to Bloemfontein is supplied in the discussion, in Chapters

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IV., V., of the political and military aspirations and attributes of the Boers, and of the situation in the South African Colonies after Stormberg, Magersfontein and Colenso. The first few weeks of the war were productive of so many surprises, and of so many movements of the centre of gravity of both thought and action, that this revision of the situation is of great use in helping the reader to understand the motives of those with whom the future conduct of operations rested and the difficulties with which they found themselves suddenly confronted. The resolute grasp of the existing situation, and the energetic advantage taken of the enemy's moral inferiority, led to rapid and almost uninterrupted successes to the west of the Drakensberg; the lack of such appreciation on the Natal side produced vacillation with inevitable reverses and unnecessary losses.

The historical account of the actual operations in this volume falls into three divisions;—the operations in the Cape Colony, the campaign in Natal, and the evolution of Lord Roberts' plan; and thus brings us up to the Relief of Ladysmith and the occupation of Bloemfontein.

The first of these three divisions and the story of Ladysmith are contributed by Mr. Lionel James, Buller's campaign by Mr. Bron Herbert, and Lord Roberts' operations by two anonymous writers.

The important political effects of French's success in checking the Boers about Colesberg, and thereby preventing the further invasion of Cape Colony and the rising of the disloyal Colonists, are well brought out in Chapter VI. Commencing with almost a handful of troops, and with his mounted force never more than a third of that opposed to him though comprising half his own strength, he succeeded in bluffing the enemy from November 20th to February 12th. The full and continuous utilization of his whole force was the secret of his success; no other general at that stage of the war brought a larger proportion of his men into the firing line at the point of attack or wasted fewer on his communications and containing forces. The moral effect of French's action brought about the strategical result of inducing the enemy to believe that the British advance would be by Norval's Pont and to denude the rest of the Orange Free State of troops so as to reinforce those at Colesberg, thus facilitating the concentration and surprise movements of Roberts' column at the most critical period of the campaign.

In Mr. Lionel James' story of the siege of Ladysmith it is pleasant to find at last the actual practical value of the Naval Artillery to the defence not magnified beyond its true proportion. The importance of Platrand to the defenders seems however to have been underrated by the historian, as it seems also to have been by Ian Hamilton at first. Its capture by the Boers on January 6th would have probably had the most serious effect. The writer says that the permanent occupation of Wagon Hill itself, or even of the southern crest of Cæsar's Camp, would not have involved the fall of Ladysmith. This is rather avoiding the real issue. The permanent occupation of the southern crest would have proved the inability of the exhausted defenders to drive off the attack, and doubtless reinforcements of fresh men would have led to the permanent occupation of the whole hill. From it the English western line of defence from Red Hill to Ration Post would have been enfiladed, while the northern defences from King's Post to Devon Post would have been taken in reverse at 5,000 yards

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range, and the interior communications of the garrison would have been at the mercy of the enemy's rifle fire. It would seem therefore that the Boers were justified in making a strenuous effort to capture this, the key of the defence, and their failure accounts for the half-hearted nature of the last part of the siege; while it is clear that no efforts or sacrifices on the part of the besieged were too great to retain this vital point in their possession.

Hardly enough credit seems to be given to General Hunter, to whose untiring devotion and resourceful skill the successful maintenance of the defence was unquestionably due, and his portrait might well have replaced one of the less remarkable of those facing p. 166.

In the Chapter on the Tugela operations there is an impartiality about the occasional comments and, generally speaking, a correctness in fitting the boots on the right legs, as well as an accuracy in description of tactical details, which have been hitherto too often conspicuous by their absence. The criticisms are outspoken and the strictures sometimes severe, but the truth is summed up in the remark that "Spion Kop was lost not by Buller or Warren or Thorneycroft but by Aldershot and Pall Mall, by the House of Commons and the nation."

Complete ignorance or disregard of the elementary principles of scientific organization and of staff work essential to the handling of large bodies of troops in the field,—want of confidence by the leaders in their own powers of leadership,—lack of rapidity of movement when surprise was a chief factor,—absence of initiative on the part of the subordinate generals in carrying out the section of operations assigned to them,—unwillingness to push into the fight all the troops available, in other words misconception of the use of reserves,—avoidance of losses carried to an absurd extreme, or the attempt to make omelettes without breaking eggs,—inability of the generals to use Artillery and Infantry in combination,—utter failure and breakdown of intelligence and reconnaissance work,—supineness in transmitting information in the field,—these are all in turn insisted on as causes of failure rather than the deficiencies in the subordinate leaders and rank and file. We may perhaps add to the above the old British manœuvre habit of breaking off the fight in time to be home for tea, sometimes at the most critical moment when victory was just within grasp. "The battle of Vaal Krantz," writes Mr. Herbert, "was lost in the very moment of victory." It is difficult however to understand the severe stricture on the qualities of the British soldier which we find on p. 298. "Neither in skill with the rifle, nor in individual intelligence and initiative, nor in physical and moral endurance was the British soldier equal to the terribly exacting demands of modern warfare. The constant reinforcement of the summit of Spion Kop only increased the overcrowding, added to the casualties and contributed to the demoralization of a considerable part of the force. Yet on the other hand a smaller force of the same men would have been rushed off the summit by the Boers. Spion Kop might have been held against all comers by 500 men, but not by 500 ordinary British soldiers, nor by 5,000." This appears to be a blot in an otherwise calmly and judicially told story. It can hardly be the meaning of the writer to discount the courage of the British soldier, and it would be an insult to Mr. Herbert's

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intelligence to suppose that he considers 500 heroes of any nation would have held Spion Kop unaided against the attacks made by the Boers on the 24th January. Has he forgotten that the hill was held by the British force there, considerably less than 5,000 men, for 15 hours under heavy artillery and rifle fire from 3 sides; and that this force retired in good order at night under instructions from their properly appointed commander, bringing away all the wounded that could bear moving and the reserve ammunition; and that there was no panic or demoralization among the rank and file at any rate. Nor is the above opinion of the British soldier consistent with the closing words on the Tugela Campaign on page 552. "The deficiencies of the British officer and of the men whom he led were many, and they have been dealt with in more than one chapter. But their deficiencies were, after all, completely overshadowed by their virtues; and it was these virtues that, in the end, broke the Boer resistance and relieved Ladysmith. Their fearless courage, their patient endurance, their imperturbable cheerfulness in defeat, their unquestioning loyalty to their leader lend dignity and pathos to a story, most of which would otherwise be profoundly depressing, and give sure hope of better things. If there is one clear lesson we may draw from the Tugela Campaign, it is that British soldiers, trained as they might be trained and led with courage and science, need fear to match themselves with no army in the world." Probably there is some printer's error which has escaped correction in the sentence quoted from page 298.

The history of Roberts' great flank march and successful advance to Bloemfontein has been written anonymously, but the writing bears evidence of being from the pens of soldiers rather than civilians. There is a more military precision in the details, and less bitterness in the criticisms than in the rest of the book. The plain unvarnished tale of French's charge at Klip Drift reminds one of Henderson's accounts of Stuart's exploits in the American War. Calm and straightforward criticism of Kitchener's and Roberts' tactics and strategy at Paardeberg, and of French's and Kelly-Kenny's over-caution at Poplar Grove, appeal to the military reader with greater force than the mere scathing flagellation of the delinquents on the Tugela. It would be difficult to find eulogy of a great success expressed more forcibly or with more dignity than on page 595. "This was Lord Roberts' work. To him and to no one else England owed this great result. Circumstances may seem to have favoured him; each one of his successes owed much to the skill and determination of his subordinates. But it was he, the man himself, who seized the favouring chance and directed it to his ends, whose bold designs furnished skill with meet occasion, whose quick spirit kindled a responsive fire. Boldness of conception, singleness of aim, fervour in execution, fearlessness of responsibility—these were the qualities Roberts brought to bear on a situation fatally compromised and entangled by original unpreparedness and subsequent failure, and it was by these that he turned defeat into victory."

G. H. SIM.

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NOTICES OF MAGAZINES.

Building World.

May 13th and June 3rd.

Maximum Load Due to a Crowd.—The results are given of some experiments carried out at Harvard University, U.S.A., to ascertain how great a load of people may be crowded within a given space.

With men allowed to face in various directions a maximum load of 156 lbs. per sq. ft. was obtained. With men facing all one way the load was equal to 176·4 lbs. per sq. ft., and with men averaging 163·2 lbs. each the maximum load was 181·3 lbs. per sq. ft.

These figures are greater than those given in Molesworth's, and the R.E. Field Service Pocket Books, which are respectively 120 lbs. per sq. ft. and 133 lbs. per sq. ft.

N. Kirby.

Fortnightly Review.

June.

A Century of Empire is a thoughtful contribution (*written a year ago*) by Major-General Sir Thomas Fraser, K.C.B., late R.E., on the increasingly important subjects of Imperial Defence and Home Defence. The leading newspapers and magazines perform their most honourable duty to the State in publishing such articles as this, but unfortunately the general public seldom reads them; it is only a comparatively small section of the great B.P. that seriously studies the question of Defence, or realises how absolutely vital it may become at any moment to the Nation and to the Empire; the rest—the "man in the street"—prefers to read or hear the misleading though comforting misapplications of principles by influential civilians.

The writer forcibly draws attention to the fact that, whereas a century ago we were the absolutely supreme Naval power, we are now the greatest Continental one, possessing inland frontiers which require protection from most of the great military Powers of Europe, Asia and America. At the commencement of the 19th century our continental footholds (exclusive of India, where we bordered native states of comparative insignificance, and Canada, where we marched with people of our own race) were two in South Africa (the Cape and Sierra Leone) and

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one in Central America (Honduras). At that time, with a third of our present population, we maintained a million armed men; but after Waterloo the maintenance of this great military strength was no longer necessary, as we were then secure from attacks on land.

Since that time the whole situation has changed. Our share of the earth's surface has grown to $\frac{1}{8}$th of the whole and the populations under our rule to about 450 millions,—far exceeding in both respects the next power in extent, Russia, with $\frac{1}{7}$th of the earth and 140 millions of inhabitants. We now march *on land* with all the great military and naval powers, except Austria and Japan; our frontiers extend from 25,000 to 27,000 miles, bringing us into contact with 1,200 millions of people in three continents, principally under the spheres of China, France, Germany, Italy, Turkey, Russia and the United States. We are thus attackable on land *independently of sea power.*

In the meantime other factors have affected us, mostly adversely, as regards self-defence. The world has shrunk under the influence of steam and electricity. Land transport has relatively gained more than sea transport by the use of steam; railways now permit the transfer of large forces over long distances, and even enable a power deprived of the open sea to transport small war vessels over land. Though steam in place of sails has increased the speed of ships, steam navies, dependent on coal, are tied to the land, to the great trade routes or to the lines of coaling stations; warships are so expensive that they cannot be risked against equally well-armed land defences, and they are now, moreover, more liable to unexpected attacks in open harbours and narrow waters; all of which has rendered less certain the forecasting of results of warfare on sea. Though we are still the greatest naval power at present, other great navies have arisen or are arising to front rank; we have practically reached the limit of expenditure on our navy, but other nations have not; and the strong conscript armies of most of these other nations afford greater support to the offensive power of their fleets. The lax interpretation of the duties of neutrals may enable our enemies to utilize neutrals in such a way as to render nugatory the many advantages we assume that we possess. We are no longer alone in possessing for defensive and offensive purposes the strength afforded by armed forces of our subject races.

And withal our Empire has grown on the commercial lines of least resistance and not on strategical lines; it is relatively scattered, and ill-grouped for defence as a whole. "We sleep in a security that was ours a century ago, but is ours no longer." Three times our present naval strength cannot protect us on land where we can be invaded on land beyond the reach of our naval strength. Conflicts must in the main be decided on land. No navy can relieve us of the necessity of possessing considerable and efficient land forces as well. The great lesson of the present war in the Far East is that decisive results are impossible unless *both* military and naval forces are in proportion to needs.

The theory of the "blue-water school" is that our theatres of war comprise the oceans of the world, our frontiers the coasts of our enemies, and our objectives the enemies' ships. This means that our fleets must be

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freed for action where required, and the theory may meet the case of Imperial Defence. But can we also count at Home, *at all times and uninterruptedly*, on superior sea power to protect us at Home on land?

There is no alternative for us but to accept the principle of personal obligation to defend our homes. At present the leisured upper classes provide our officers and the least successful in the labour market provide the majority of our men, whilst the great middle class as a whole do nothing personally towards their duty to their country. There is no remedy except the formation of an army at Home, properly organised, trained on one system, and exercised annually. This and this only will meet our requirements and produce the required reserve of strength.

A. T. MOORE.

GEOGRAPHICAL JOURNAL.

June.

THE PROBLEM OF THE UPPER YANG-TZE PROVINCES AND THEIR COMMUNICATIONS is a paper read at a Meeting of the Royal Geographical Society by Lieut.-Colonel C. C. Manifold, I.M.S., describing a journey made in 1904 by himself, with Capts. E. Barnardiston and E. W. S. Mahon, R.E., Mr. C. G. Nix and five Indian surveyors. The exploration was in continuance of journeys made by the same traveller in 1900 and 1901–02 to the Upper Yang-tze, starting in one instance from Burma and in the other from the Yellow River; and extended the information procured by Capt. C. G. W. Hunter, R.E., the late Capt. W. A. Watts-Jones, R.E., Major H. R. Davies, O.L.I., and others. The journey here described was for the special purpose of investigating Se-chuan, the largest and most wealthy of the eighteen provinces of China.

THE IDEAL TOPOGRAPHICAL MAP is a paper read before the Research Committee of the Society by Major C. F. Close, C.M.G., R.E. (head of the Topographical Section of the General Staff). The author considers that a topographical map should possess the following qualities:—

(1). All the information which it presents should be accurate.
(2). It should present as much information as possible.
(3). The information should be presented as intelligently as possible.

The first quality mainly depends upon the methods used in the field.

As regards the amount of information, the governing factors are the scale of the map and the character of the country. It is suggested that the wide margins in common use might be utilized for presenting additional information in the form of photographs of typical scenery and of special objects or landmarks.

Intelligibility rests mostly on the use of colours and the shading of the hill features; as regards the latter, the depth of the shade should vary with the steepness of the slope and should not depend on any imaginary direction

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of the incident light; there is no satisfactory example of the best system, viz., the combination of contours and shade varying with steepness. Contour intervals should be 50 feet for a scale of 1 inch to 1 mile, and in inverse proportions for other scales.

Various British and Foreign productions are quoted as instances of efficient maps or of omissions and defects.

The paper was followed by an instructive discussion in which Colonel D. A. Johnston, C.B. (Director-General of the Ordnance Survey), Major E. H. Hills, C.M.G., R.E. (late head of the Topographical Section of the General Staff), Mr. Douglas Freshfield, Mr. E. A. Reeves (Map Curator of the Society) and others took part; and resulted in the Committee recommending that the Society should vote £100 for the purpose of producing what might be accepted generally as a typical topographical map that would serve as a guide for, and a standard to be used by, the Society.

GLAREANUS.—Mr. Edw. Heawood, Librarian of the Society, writes of the Geography and Maps of Henricus Glareanus, with special reference to the recently discovered manuscripts of his *De Geographia Liber* (see *R.E. Journal* of last month).

A. T. MOORE.

JOURNAL DES SCIENCES MILITAIRES.

April, 1905.

STRATEGICAL CRITICISM OF THE FRANCO-GERMAN WAR.—*II. Woerth and Forbach.*—By M. A. Grouard.—The writer aims at shewing that at Woerth MacMahon's proper course was to retire to the more advantageous positions behind the Eberbach, along the Gros Wald and about Ingwiller, and not to accept battle on the 6th August. He was outnumbered by the Germans by more than two to one, and expected very insignificant reinforcements. This course had been strongly urged on him by Ducrot, and he had agreed and actually given orders for the retirement; but when the firing commenced, he changed his mind and committed himself to a battle of which the only possible result could be the crushing of his force. Even up to one o'clock MacMahon could have broken off the action at any time; but after the envelopment of the French right through Morsbronn, the failure of Michel's grand cavalry charge to extricate the right of the 4th Division, and the development of the close fight in the Niederwald and at Elsasshausen, an orderly retreat was no longer possible. The tactical discussion of the principal phases of the battle is directed towards establishing the time up to which it was possible to retire in good order.

At Forbach (Spicheren) on the other hand, the French had at first a quite inferior force of the enemy opposed to them, and this could only be reinforced gradually after crossing a difficult river, the Sarre. The

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cause of defeat in this case therefore lay in the conduct of the action itself, and not in faulty strategy as at Woerth.

EVOLUTION OF FRENCH INFANTRY TACTICS FROM 1791 TO 1905.—This is the third and concluding article of the series and deals with the developments from 1901 to 1905. The Infantry regulations of 1894 were superseded by the provisional issue of 1902, and again improved up to date in December, 1904. It does not appear that the principles differ materially from our own field training. Volley firing has practically been abolished. As far as possible all formations and movements which are inapplicable in war are to be excluded from peace training. The initiative of captains of companies and section leaders is encouraged. The battalion commander in the attack indicates the front of action (not generally to exceed 300 yards for 800 men), tells off the companies for first line and support, gives all officers full instructions as to objective and direction arranges for the scouting sections if the country is not too open, and for ammunition distribution and replenishment, and then leaves the carrying out of the fight to the subordinate leaders. The chief principles insisted on are that :—

Initiative is everything, and the offensive is the grand function of Infantry. The defensive is only to be assumed temporarily as preparation for resuming the offensive.

Fire is but an auxiliary to movement, and it is the advance only that is decisive and irresistible.

The direction of the fight is always in the hands of the leading sections. Subject to the general instructions received and the co-operation of those on each flank, the section leaders must be fully independent, and must use the ground features intelligently and seize opportunities on their own initiative.

At the commencement of the regulations appears this important order :—"It is forbidden to curtail or to expand by more precise detail the instructions contained in these regulations, which prescribe the method of training the different units and of leading them in action."

ARTILLERY ESCORTS (*3rd Article*).—Cavalry escorts should send scouts well in advance of field batteries, keeping the main body in hand on the exposed flank, ready to charge attacking cavalry if inferior in strength or use dismounted fire if the enemy is in force. With horse artillery the cavalry escort should send scouts far ahead during the advance, the remainder of the escort preceding the batteries to use vigorous action against any opposition, so as to enable the guns to come into action. When the batteries are in action the main body of the escort can be withdrawn and rejoin the Cavalry unit, for if the horse artillery has timely intimation of attack it can meet it with its own fire.

Artillery ought to be able to protect its own front against a frontal charge even up to close quarters, with shrapnel fused to zero; but the smoke produced by the bursting of these shells close in front of the

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battery is likely to make a screen for the enemy's approach. It seems a pity therefore that the modern equipment has abolished case. Half-a-dozen rounds in the limber might often prove useful.

The great improvements made lately in mitrailleuses have led many nations to attach them permanently to their Cavalry and Mounted Infantry units. It is suggested that they may also prove a valuable form of escort for Field Artillery. Their lightness, mobility and fire power would render them useful during the march to check an attack from any flank or to clear defiles; while batteries in action could have their fronts protected by them from the flanks, or their flanks and dead angles secured. Against cavalry charges they would be efficacious, and also for protection of Artillery in bivouac or park at night, when it is very exposed to attack. They can generally fight from concealed positions and so minimise their vulnerability; or, if provided with steel shields, can even be used in exposed positions. Each battery might well be provided with its own mitrailleuse. This would go far to solve the difficulties of the provision of Cavalry or Mounted Infantry escorts except for scouting purposes. Mitrailleuses might be specially useful in preventing the enemy's infantry occupying a position, such as the edge of a wood, whence they can annoy the artillery; for it must be remembered that, if the enemy can bring infantry fire, even in small amount, within 1,000 yards of a battery, he can put it out of action without any actual attack.

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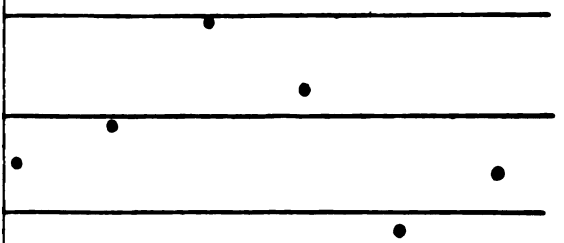

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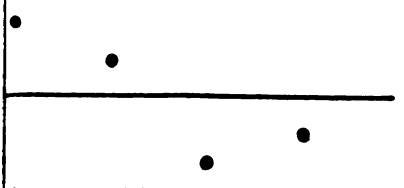

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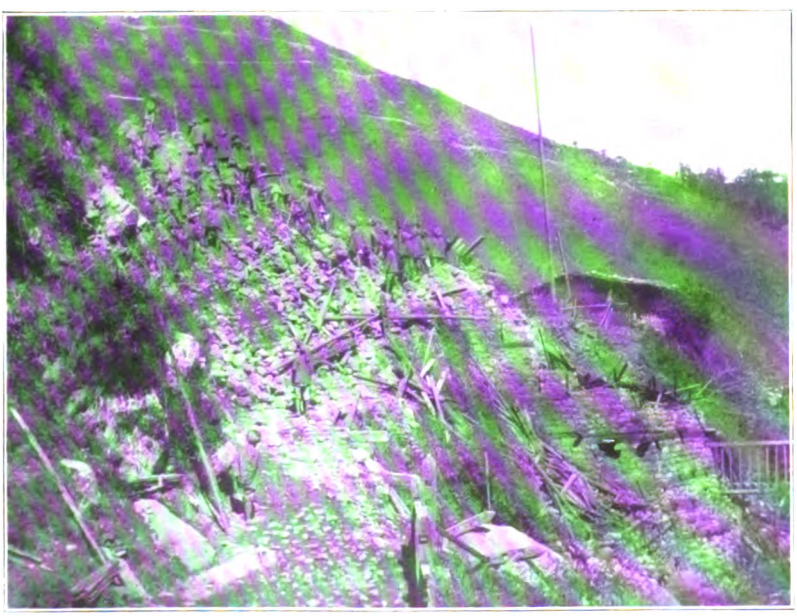
Chinese wall at Yatung before demolition.



Chinese wall at Yatung after demolition.

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TRAINING AND ORGANISATION OF MILITARY ENGINEERS.

By Capt. J. E. E. Craster, R.E.

In writing this article, I have throughout been oppressed by the knowledge that the majority of my readers must know far more about the subject than I. Moreover, the work has not been rendered easier by the absence of any books on the subject; at least, if any exist, I have so far failed to discover them. It will be obvious, therefore, that I have had to rely solely on my own limited experience, and that I have no other authority to support the views I have put forward.

I will begin by stating an axiom :—

Military Engineers must be organised and trained for war.

It is necessary to commence in this way, because the fact that war is the end and aim of a sapper's training is sometimes lost sight of in the details and ramifications of engineer organisation. Difficulties occur not in the recognition of the principle but in its application.

The obvious deduction from the foregoing axiom is that a military engineer should in peace time be employed, as far as possible, on the same work that he will be required to do in war. What that work will be cannot be accurately foreseen. This is the unknown quantity in the problem. In order to lend an air of mathematical precision to our deliberations, let us call it X.

Unfortunately, the most difficult part of the solution is still before us.

Statistics of previous operations would, undoubtedly, help us to arrive at a rough approximation of the value of X, for any particular case. Or to put it more explicitly,—it would be very useful, at the end of a campaign, to have a rough record compiled, shewing the way in which the sappers spent their time, and the percentage of the whole that was devoted to each class of work. In order to facilitate comparisons, diagrams might be prepared for each campaign as illustrated below :—

Group I.						Group II.				Group III.	
Purely Military Engineering.						Common to Civil and Military Engineering.				Non-effective.	
Field Fortification.	Siege Works.	Field Bridging.	Hutting.	Camp Water Supply.	Balloons.	Roads.	Railways.	Telegraphs and Telephones.	Reconnaissance, Survey and Reproduction of Maps.	Sick.	Prisoners of War.

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The space which I have devoted to each heading is purely arbitrary, and I do not pretend that I have included all the various duties which the sappers are expected to perform.

The list, though incomplete, is a long one, and shews that a sapper's duties in war are many and various; therefore his occupations in peace time must be many and various also.

It happens that sometimes the cheapest and most remunerative way of employing him in peace is also the best way of training him for his duties in war. This is merely a fortunate coincidence. Fortunate in one way, yet extremely unfortunate in another, for it has at times brought about a confusion of ideas among the British public, who are the ultimate controllers of the engineers' destinies. They have, in fact, not infrequently mistaken the earning of by-profits as the main object of an engineer's existence, and have therefore concluded that a sapper should always be employed during peace in the most remunerative way. They have forgotten that they must train him for war.

The military training of an engineer officer should be equal to, if not better than, that received by officers in other branches of the Army. By military training I mean training in strategy, tactics, and the art of war generally. In field fortification he should of course be an expert. It is far more important that he should fully understand the tactical uses of fortification than that he should have at his fingers' ends all the types of works shewn in the text books. The site of the work to be executed is of infinitely more importance than the details of its construction; the latter do not, as a rule, call for the exercise of any great talent.

The necessity for impressing engineer officers with the tactical uses and abuses of fortifications cannot be too strongly insisted on. Too much fortification is as bad a fault as too little. The fatal attraction that earthworks have for troops may be great enough to cause them to voluntarily give up their mobility, and with it all chance of winning a victory. Fortifications are at best only a prop that enables the weaker force to keep the field. The engineer should therefore regard his handiwork with no exaggerated esteem. I do not mean that he should despise or neglect his own special work; it is on his merits as an engineer that he is valued by the other branches of the service. This is well illustrated by the following extract from Napier's *Peninsular War*:—"The engineer officers were exceedingly zealous, and notwithstanding some defects in the constitution and customs of their corps, tending rather to make them regimental than practical scientific officers, many of them were very well versed in the theory of their business."

Though a few engineer officers are fortunate enough to obtain staff appointments, the great majority must look to their own particular line for their advancement. There may be a Napoleon among them;

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but if he does not in the first instance distinguish himself as an engineer, it is likely that his secret will be buried with him.

I find I have strayed from the line marked out by the heading of this article, so I will hark back to the diagram. The various duties that it includes may be divided into two classes; those which are purely military, and those which are common to both civil and military engineering. The former includes field fortifications, siege works, bridging, hutting, water supply and balloons; the latter roads, railways, telegraphs and telephones, survey and the reproduction of maps.

Of the duties included in the first category, two are so technical that special units are set apart for their performance. In order that the bridging and balloon companies may maintain a sufficiently high standard of efficiency, they must be employed for the whole, or nearly the whole year, at their own special duties; they cannot, with advantage, be employed in any civil or semi-civil occupation. The remainder of the duties in the first group do not demand such constant practice, and it should be sufficient if both officers and men were put through an annual course of instruction. This leaves them free, for the greater part of the year, to practise the duties enumerated in the second group, which I propose to discuss at greater length.

Few opportunities occur for road-making in civilised countries. In India sapper companies are still often employed on road-making during peace; but on the whole the demand for roads has decreased, and we may anticipate that, as the world's railway system develops, it will shrink still more.

The construction, maintenance and working of railways will in the future monopolise a great deal of the time and labour of military engineers. For this work some special units are required. Railway companies, composed of railway specialists, are necessary to form a nucleus for a railway corps; but the expense of maintaining a sufficient number of railway companies to work unaided any but the smallest railway system is prohibitive. The railway companies must therefore look to the field and fortress companies, to auxiliary railway troops and to civilians for assistance in repairing and working the railways committed to their charge. For this reason, it is desirable that both officers and men of the field and fortress companies should obtain practical experience of railway work during peace. The survey, design and construction of new railways, besides affording valuable technical experience, gives more opportunities than any other form of employment of learning and practising useful engineering. I trust I may be permitted to suggest that we have not enough officers or men employed on railways at home. Few opportunities for employing military engineers are forthcoming, because English railways are all in private hands. It might, perhaps, be possible, when Parliament sanctioned a bill for a new railway, to have a clause inserted

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guaranteeing that certain portions of the work should be performed by military engineers.

Railways exist primarily for the benefit of the public. This fundamental principle is daily receiving wider recognition, and, consequently, it is probable that the State will in future exercise more control over their administration than it has done in the past. There are grounds for hoping, therefore, that the opportunities for employing military engineers on railways will increase.

The huge area occupied by a modern battle has necessitated the use of telegraphs and telephones to maintain communication between the various parts of the field. A telephone system will probably form part of the equipment of every outpost line; no defensive position will be considered complete without one. The erection of lines, and of simple telegraph and telephone installations, should form a part of every sapper's training. The construction and working of the main telegraph lines connecting the forces with their base would be, as hitherto, the special duty of the telegraph companies, of whom a considerable proportion (if not the majority) of both officers and men may be usefully and economically employed during peace on the civil postal telegraph and telephone systems.

The Ordnance Survey and various colonial surveys afford good training for officers and men in survey work. This training is supplemented by instruction in field sketching and reconnaissance. The men employed on the outdoor duties of the Ordnance Survey develop a facility for map reading, a keenness of vision and a sense of direction that should render them extremely useful as guides or scouts or for any reconnaissance duties. The reproduction of maps in the field is a matter of the greatest importance, and must not be overlooked during peace.

I have now come to the end of the duties shewn on the diagram. I have attempted to shew that, to keep pace with modern developments, increased attention must be paid to railways, telegraphs and telephones, and that a large proportion of officers and men may advantageously be employed on the former during peace time.

Engineer organisation in the field I propose to deal with in the briefest and most general terms. I have no desire to flounder into a morass of detail, or to amuse my readers and weary myself by the construction of a formidable diagram to shew through what tortuous channels the C.R.E. of an Army Corps should communicate his orders to the last-joined subaltern,—a diagram which, when finished, might be mistaken at a short distance for an aristocratic pedigree.

In brief, the whole of the engineer organisation in the field must be under one central authority, a C.R.E. or (as I should prefer to call him, to distinguish him from other and lesser C.R.Es.) the Chief Engineer. He must, of course, be on the staff of the Commander-in-Chief. His most important duty will be to adjudicate between the

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rival claims of the various engineer branches. It must be remembered that railways, telegraphs, survey, balloons, field companies, and in fact every engineer unit, will be clamouring for engineer officers and men. In addition the commander of every small post, who at manœuvres does not know what on earth to do with a section of sappers, finds on service that he does not know what on earth to do without them; and he, accordingly, adds his voice to the general clamour. The chief engineer, therefore, must control the distribution of *personnel* and must concentrate his officers and men on the most urgent work; this is essential to economy and efficiency. In other respects the various branches must be as decentralised as possible. In nine cases out of ten, the man on the spot knows best what to do, and he should be encouraged to do it without delay and on his own authority.

Let us turn aside for a moment to examine a rival system, organised on utterly different lines,—a system which has often been held up to us as the ideal at which we should aim. The German engineers are organised on the water-tight compartment basis; for each engineer duty there exists a separate corps. The pioneers, who correspond roughly to our field companies, confine their efforts to field works, demolitions and bridging. The railway battalions, being a totally distinct branch of the service, do not expect, or certainly do not receive, any help from the pioneers. Telegraphs are in the charge of a third branch. These various corps have nothing in common, and to still further widen the gulf between them the rates of pay are different. They are not, apparently, under any central authority; consequently there can be no concentration of *personnel* on the most urgent business; one branch sits idle while another is worked to death.

For any expedition of moderate size, the German system cannot compare with ours for efficiency or economy, though no doubt on paper it is vastly superior to ours. Possibly in very large wars the disadvantages of the water-tight compartment system may not be so clearly marked. With such wars, however, we have no concern; for the size of the British army precludes them. For any war of a size that the British army can tackle, the water-tight compartment system of engineer organisation is bad, utterly bad.

To blindly model our forces on the lines of the German army is equivalent to building a small motor car to the design of a steam roller.

In conclusion, I would urge that the subject of engineer organisation stands in need of study and discussion. We cannot hope to make the most of the existing arrangements, or to improve upon them, if we do not appreciate the principles upon which they are based. The iconoclast is abroad, and hardly a day passes that is not marked by the disappearance of some long-established organisation.

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Yet every system which has survived the South African war has not necessarily outlived its usefulness; neither is the obliteration of the existing system always essential to the introduction of improvements. Reforms which have their origin within the organisation are likely to be more beneficial and less irksome than those which come from without.

I feel that I owe an apology to my readers—if any have borne with me thus far—for attempting to deal with a subject of which my lack of knowledge and experience has, I fear, been patent in every line. I have thrown a sprat to catch a whale. If I succeed in inducing those whose experience renders them masters of the subject to give us the benefit of their views, I shall have attained my object.

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ORGANIZATION OF ROYAL ENGINEERS FOR WAR.

By Bt.-Colonel E. R. Kenyon, R.E.

The present period of Army organization seems to be a fitting occasion for considering whether a radical change is not required in the organization of the Royal Engineers for war.

What then are the engineer duties which must be provided for in any serious war; and can our existing organization be improved without increased expense?

It is now most happily an accepted axiom that infantry and artillery must entrench themselves, not merely as working parties under engineer supervision, but as tactical units selecting and preparing their own lines of defence. Entrenching is not a duty which needs an engineer for its proper execution. The actual work is for the most part that of a labourer, not of an artisan, or, when carried to the greatest perfection, that of a navvy and not of an engineer. The planning and laying out of entrenchments requires tactical, not engineering, knowledge. Any officer who has properly studied his profession should therefore be able to do the work; and the most appropriate officer would seem to be the one who is to hold the line at the risk of the lives and honour of himself and his men. For the preparation of special posts such as villages, for the construction of redoubts, etc., the aid of engineer supervision and of a few skilled artisans may be useful. Saps, mines and obstacles will be needed, not only in siege warfare, but also in the attack and defence of field positions; but for these also the requirements are a large supply of labour under highly skilled supervision with a small percentage of trained workmen.

The preparation of camps is, as a general rule, work which can be well done by unskilled labour under the direction of a sanitary officer, and does not call for engineering knowledge or mechanical skill. Sometimes, of course, especially where large standing camps are concerned, there are important questions of water supply which need the direction of an engineer and the work of artisans and mechanics. It is therefore necessary that there shall be a small body of such men at the service of large bodies of troops when required.

It has been conclusively proved in South Africa and in Manchuria that facilities for collecting and transmitting information from one part of a fighting force to another during action, as well as during the

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preliminary movements, must be enormously increased beyond what at present exist in the British army. It is also perfectly clear that the organization, working, repair and construction of railways must play an extremely important part in all large operations of war, and that the improvement of communications of all kinds is of vital importance. For coast defence and for the attack and defence of fortresses railways will have to be utilized to a very much greater extent than hitherto.

A consideration of these points seems to lead to the conclusion that the chief strength of the Engineer force should be devoted to our *Lines of Communication* and to what we may well describe as our *Lines of Information*, with a smaller proportion for general duties.

Field and Fortress Companies should therefore either be supplemented by a large increase to the Telegraph, Railway and Bridging Companies, or should have their composition so altered as to enable them to provide Sections to deal with these special branches of our work. In fact, I think we shall find that these special duties will be of such predominant influence in future that the companies might well be re-named so as to indicate the particular branch of engineering for which each is most fully equipped. Thus one Field company might contain three sections of trained telegraph men and might therefore be called a Telegraph company; another might have three sections of railway men and be called a Railway company; and so on; each company being capable of doing general work, and yet having its own speciality which would be denoted by its designation.

As regards the Survey companies the exceedingly good work done by them both in peace and war should not blind us to the fact that to the General rapid and clear reconnaissance, and not accurate survey, is of prime importance, and we cannot have too many officers or men trained for such duty.

Submarine-mining companies are not needed now that submarine-mining has been abolished or transferred to the Navy; and they have therefore been transferred to the category of Fortress companies, so far as the Regulars are concerned. Whether submarine-mining will not have to be resuscitated as part of our land service is at least doubtful; but if it is, it will be, I hope, as part of the duties of a Coast Defence Corps, which will include garrison artillery, submarine mines and search lights under one command.

We therefore require :—

(1). Field troops to accompany detached forces of cavalry or mounted infantry, capable of constructing bridges, tapping telegraph lines, and giving any general engineering assistance that may be needed,

(2). Balloon and Telegraph companies for the Lines of Information,

(3). Bridging and Railway companies for the Lines of Communication.

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To the Bridging companies should be allotted the communications at the head of the army, *i.e.*, pontoon and comparatively light and hasty bridges. The Railway companies would have charge of all communications—roads, railways, bridges—from the base to the main body of the army.

Each engineer unit should contain officers and men capable of giving the skilled engineering and mechanical assistance which might be needed by the other arms, as stated above, at special defensive posts, for difficult water supplies, etc.

The Telegraph companies would work both telegraph and telephone lines; and by means of these would keep every part of an attacking force in close touch with the supporting troops and the commander. The telegraph lines would be run as far forward as cable carts can go; but beyond this point light telephone lines would be carried forward on drums by men, so that each battalion would be kept in touch with its neighbours, the reserves and the artillery. No one can have read the account of Spion Kop and other South African fights or of the Manchurian battles without seeing the enormous advantage that will be secured to any army which is thus bound together by a flexible chain of telephone and telegraph lines. In this way alone can the commander recover something of the personal control of the fight which at present he has lost; and by these means alone can the co-operation of infantry and artillery be perfectly secured and directed.

At present the Corps of Royal Engineers (excluding the Indian garrison) is composed as follows:—

3 Field troops.
3 Bridging companies.
3 Telegraph companies.
1 „ cadre.
1 Search Light company.
5 Balloon companies.
1 „ cadre.
1 Field depôt.
4 „ parks.
17 „ companies.
37 Fortress companies (including 17 ex-submarine-mining companies, of which 5 are local, and 1 other local company).
3 Railway companies.
4 Survey companies.
7 Depôt companies (of which 6 are double companies).
2 Militia battalions.
10 „ Submarine-Mining divisions.
31 Volunteer corps (including 7 Submarine-Mining divisions).

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In place of this distribution I would, for the Regular units, propose the following :—

4 Field troops.
12 Bridging companies.
34 Telegraph companies.
18 Balloon companies.
1 „ cadre.
1 Railway and Search Light depôt.
12 Railway companies.
7 Depôt companies.

The Militia and Volunteer companies should be maintained with a similar proportion of duties.

Thus, if we had to send abroad a force of 8 Divisions (which Mr. Balfour, as President of the Imperial Defence Committee, seems to consider the largest expeditionary force we are likely to have to despatch in the first year of the most serious war that need be contemplated), we should be able to equip it with the following proportion of engineers, which I venture to think is not extravagant in view of modern requirements :—

1 Field troop per Cavalry Brigade :	Total,	3 Field troops.
1 Bridging company per Division :	„	8 Bridging companies.
1 Telegraph company per Brigade :* 1 „ „ „ Division (as Corps troops for connecting with Divisional headquarters, with cavalry, with other Divisions, and for general use) : 1 Telegraph section per Brigade of Artillery :	„	30 Telegraph companies.
2 Balloon companies per Division :†	„	16 Balloon companies.
1 Railway company per Division :	„	8 Railway companies.

The proportion of Telegraph companies seems large, but it must be remembered that this branch is the only one which cannot be supplemented, when necessary, by labour from the other arms.

If instead of 8 Divisions we had to send 13 or more, as in the South African war, we should have (besides the Indian corps and the

* This has by actual test on Field days been found not at all excessive.

† At Nan-Shan, where the Russians had 15 battalions engaged, they had 10 balloons in use. A British balloon company can work one balloon.

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contingents which the Colonies might supply) the following reserves to draw from :—

15 Service and 9 Depôt units or cadres.
2 Militia battalions.
10 „ Submarine-Mining divisions (which may perhaps be converted to some other branch of engineering duties).
31 Volunteer corps.

I do not touch on the question how this re-organized Corps could best be employed in peace ; many obvious suggestions will present themselves to the mind. But it is the war organization which needs to be first determined, and then the peace utilization will follow. The simultaneous discussion of peace and war arrangements only leads to a consideration of side issues and the consequent postponement of the important decisions affecting war efficiency.

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No. 3 COMPANY 1st (BENGAL) SAPPERS & MINERS ON THE THIBET MISSION, 1903—1904.

By Bt.-Major S. H. Sheppard, d.s.o., R.E.

Leaving Roorkee on November 15th, 1903, the Company arrived at Siliguri three days later, and was at once sent on to work on the new cart-road below Guntok.

About December 20th it moved to Guntok itself, and commenced work on the Guntok-Lagyap road over the Nathu La into Chumbi. The rest of December and the first part of January were spent on the first mile out of Guntok; this was ordinary heavy road work, with big cuttings and a great deal of blasting. In January, 1904, the 12th Coy., 2nd Q.O. (Madras) S. & M., moved on to Chumbi, and the 3rd Coy., 1st S. & M., took over charge of the whole road from Guntok to the Nathu La, being assisted by 1,100 local coolies.

The work went on quietly and well, in the finest of weather, until the middle af February, when the Company moved to Lagyap Pass, 10,000 ft., leaving the coolies at the third mile under supervision of Lieut. A. D. Walker, R.E., and a dozen N.C.Os. and Sappers. On February 16th the first heavy snow fell, and from that time until the middle of May the men worked in the greatest discomfort, often in two feet of snow or in freezing slush over their boots. At one time it was so cold that every party had to keep a huge fire burning near them, and break off for a few minutes in every hour to thaw themselves.

However, between February 15th and the latter end of April, the following work was accomplished:—

Two miles of entirely new 6 feet trace cut from thirteenth to fifteenth miles, and paved in the Sikkim fashion; four miles of new trace cut out roughly from 15th mile to Changu; the difficult and dangerous bit from 10th mile to 13th kept open and improved; meanwhile the coolies below had completed the cart road to the fifth mile, and improved the existing mule-track up to the tenth mile.

The system of paving referred to above is, apparently, peculiar to Sikkim and Assam, and is practically a continuous Irish Bridge; large stones or logs (the latter are best for hasty work) are placed on the outside and inside of the track, and the centre filled up with stones *on edge*, very firmly wedged and hammered in; the sharp points are then beaten smooth with a big hammer, and the whole covered with sand or gravel. This remains passable in any kind of weather, and lasts for years. A certain amount of maintenance is necessary to

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keep earth spread over the stones, as otherwise mules and ponies are apt to lame themselves. On crossing to Champethang, 13,000 feet, ten miles on the Sikkim side of Chumbi, stones were difficult to find, so parts of the road were corduroyed with trunks of pine trees. Those of 9″ to 13″ diameter were chosen, as far as possible, and these were cut into 6′ lengths and laid parallel to and touching one another; such a corduroy, on a slope, has to be very firmly battened down by stout ribands at each side, or the logs will "creep," leaving awkward spaces between. This also requires to be covered with sand or gravel; otherwise the mules' feet wear off the bark of the logs and the stripped wood is very slippery in rain. I do not know of any kind of road, except Sikkim paving and corduroy, that would have been even passable during the torrential rains experienced in June and July.

On May 15th, the Company was split up; half remained with Lieuts. E. F. J. Hill and C. H. Haswell, R.E., in the Chumbi Valley; and a composite half-company under Capt. Sheppard, consisting of 60 rank and file from the 3rd Coy., 1st S. & M., and 20 rank and file (under Lieut. J. A. Garstin, R.E.), 12th Coy., 2nd S. & M., proceeded to Gyantse.

Lieut. Hill's party, for the next five months, were continuously employed on road-work on both sides of Chumbi; they also built some log huts at Champethang, as well as a log hospital, 100′ × 14′. The latter was made of logs laid horizontally, one on another, between uprights fixed at 10′ intervals; the walls were plastered with mud, and the roof made of weather boarding; this hut stood the rains excellently. This party also had an exceedingly difficult bit of road, about a mile in length and some 8 miles from Chumbi towards Gyantse, practically the whole of which had to be blasted out of granite cliffs.

Meanwhile the other half coy., under Capt. Sheppard, marched from Chumbi to Gyantse, with a small relief column commanded by Major Peterson, D.S.O., 32nd Pioneers, arriving at the latter place on May 24th, after having exchanged a few shots with the enemy *en route* at the village of Naini.

The garrison of Gyantse (*Plate* I., *Fig.* 1) were, at that time, subjected to daily bombardment from rifles, jingals, and small cannon mounted in the Jong, which dominated the Mission Post from a distance of about 1,000 yards. The effect produced by this bombardment was small, owing to the defences and traverses constructed by Capts. C. H. D. Ryder and H. McC. Cowie, R.E., who were on survey duty with the Mission. A strong house (known as Gurkha Post) had been taken by our troops a short time previously and converted into an excellent outpost; but on all other sides the Thibetans had occupied and fortified houses and villages, whence they harassed the *dâk* patrols and foraging parties.

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CAPTURE OF PALLA VILLAGE.

The most serious menace was the fortified village of Palla, which was situated about 1,000 yards to the N.E. of the Mission Post; this village had been strongly loopholed and sangared; and with our glasses we could see its garrison preparing to mount jingals and small cannon, which would have enfiladed many of the defences of the Mission Post. It was therefore determined to storm Palla in the early morning of May 26th.

The attacking column was composed of:—

Two 1st line storming (explosive) parties, of one officer and four sappers each; two 2nd line ditto, some 30 yards behind; two assaulting columns, each of an officer and sixty men of the 32nd Pioneers; with a general reserve on Gun Hill, consisting of the rest of the half-coy. Sappers, two 7-pr. guns, a company of 8th Gurkhas, and a company of 32nd Pioneers.

It was decided that the attack should be delivered on the side furthest from the Mission Post, as it was hoped that the defences might be weaker on that side. The orders were that houses **A** and **B** were to be tackled first, and that, when breaches had been made by the explosive parties, the assaulting columns should at once enter them and storm the houses.

The night march was commenced at 2.30 a.m., a long circuit being taken to the south; it was carried out very successfully, and the column arrived within 300 yards of their objective before the garrison had any inkling of attack. The storming parties then approached the village, and arrived safely at the courtyard wall shown in sketch; they then separated, No. 1 going round **A** and blowing in a breach at **1**, whilst No. 2 made an opening at **2** in house **B**; No. 2 party was also fortunately able to secure the door of house **A** on their way.

The storming parties then went back to collect and direct the assaulting columns; but it was found that the latter, owing to the darkness and the heavy fire, had gone astray, and only about twenty men in all (Sappers and Pioneers) could be found. With these it was impossible to assault both houses, so it was determined to take **A** only at first. On reconnoitering this, it was found that the defenders (some 50 or 60 Thibetans) had taken post on the upper floors and roof, carrying the ladders up with them. A box of guncotton was therefore exploded in the centre of the ground floor; this killed or buried half the garrison, and the rest were either bayoneted in the house or shot as they fled.

A good many casualties occurred doing this fight, and shortly after the capture of the house **A** our force holding it consisted only of two British officers (Capt. Sheppard, R.E., and Lieut. Gurdon, 32nd Pioneers), eight Sappers, and eleven Pioneers unwounded; Lieut. Garstin, R.E., had been mortally, Capt. O'Connor, R.A., and Lieut.

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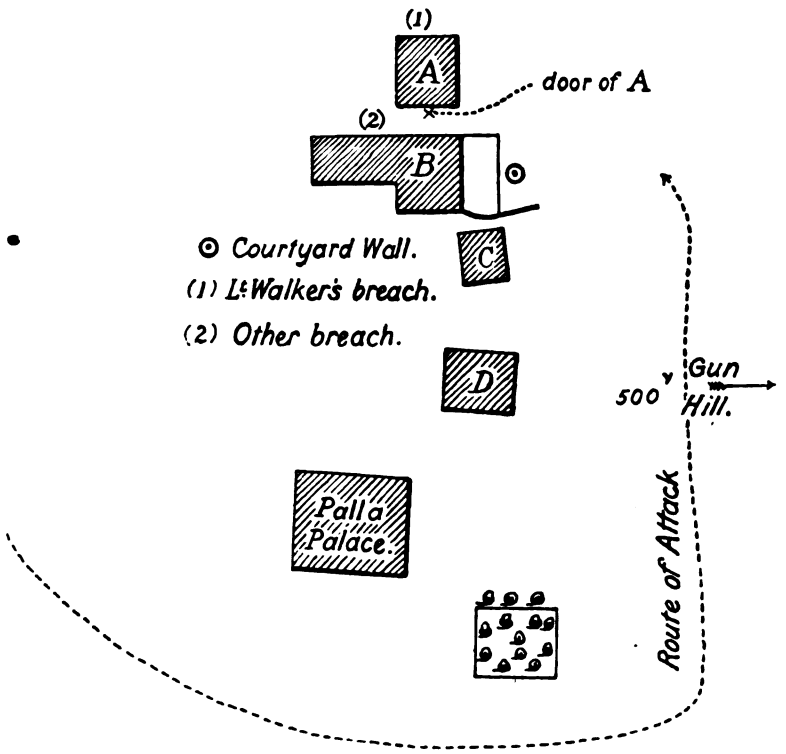
Mitchell, 32nd Pioneers, severely, and Lieut. Walker, R.E., slightly wounded, also one Sapper and four Pioneers wounded; and nearly every man of the storming parties had been hit with stones and heavy bricks, and was more or less knocked about. Under these circumstances, it was only possible to hold house **A**, and look out for counter-attacks from the Jong.



Meanwhile Major Peterson, 32nd Pioneers, commenced an attack on Palla Palace and house **D**; and with the aid of the guns from Gun Hill, took both with small loss. Houses **B** and **C** then surrendered. Some sappers did good service in carrying down boxes of guncotton, under fire, from Gun Hill to Major Peterson's party.

The first thing required after the Palla fight was a bridge over the river, as the Thibetan bridge was rendered unsafe by the guns from the Jong. The width of the river at that time was about 150′, with numerous subsidiary streams; the only timber available was that obtained from houses in the vicinity, none of which exceeded 15′ in length. So a bridge of crib piers, with numerous short spans was decided upon, and was constructed in three days with the aid of working parties from the troops (*Plate* I., *Fig.* 2). It lasted until after the Jong was taken, when there was no further need for it as the Thibetan bridge was available.

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Having completed the bridge, a covered way to Palla (now converted into an outpost held by the 32nd Pioneers) was taken in hand. As this had to be made through perfectly open ground, with no cover of any sort and only 600 yards from the outlying houses and gardens at the foot of the Jong, it was impossible to construct it entirely by daylight. At dusk tracing tapes were stretched along the ground in the required direction, and just before dark working parties were extended, the men being at 6′ intervals; each man then dug a hole 3′ × 3′ × 3′. Next morning, just before light, these holes were occupied by working parties, who joined them up to one another, thereby making a continuous trench 3′ × 3′; another working party in rear widened and deepened the work of the day before. In this manner the covered way was completed in about four days, with only one casualty, though the Jong kept up a continuous fire on the working parties. The covered way **B** was easy, as it was fairly well protected by trees, and so could be got out in daylight; both **A** and **B** were eventually made 6′ wide and 4′ deep, with numerous crossing places 8′ wide.

The 8th Gurkhas had already constructed a brick and sod wall as a covered way (**C**) to their Post; but on the Thibetans occupying a house some 400 yards beyond the Post, this wall was enfiladed, and had to be re-built in zigzags. This work was done in one day, under a very heavy though erratic fire from the Jong, during which one sapper was killed by a dropping bullet.

Besides the above, many other operations were carried out. Palla was fortified, and all outlying houses demolished; many villages and fortified houses in the neighbourhood were dismantled; a machicouli gallery was built, under heavy fire, in the Gurkha Post; the defences of the Mission Post were improved and strengthened; portions of the enemy's water supply were cut at night; and many trees between the Mission and Gurkha Posts were cleared away. The latter work had to be done after dark, as the trees in question were only half a mile from the Jong; and once the cutting party were in considerable danger, as they only returned to the Post half an hour before a night attack was made by the Thibetans over the ground where the trees stood. The enemy several times attempted to fill in the Palla covered way, and once managed to flood a portion of it, but communication was always quickly restored.

On June 26th Brig.-General J. R. L. Macdonald, R.E., in chief military command, arrived with a relieving column, having stormed Naini Monastery *en route*, and the next event of importance was the taking of Tzechen Monastery. The 8th Gurkhas attacked this from a ridge to the south, while the 40th Pathans and Sappers made a frontal attack across the plain. The fire was very heavy, though wild; the monastery and fort on the top of the hill were reached with the loss of one officer only (Capt. Craster, 40th Pathans) by the

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frontal attack, though the Gurkhas had several casualties on the ridge.

The large charges of guncotton (whole boxes) used at the Palla fight had apparently inspired the Thibetans with a wholesome terror of the explosive, and it was found that they never again stood in a house after an entrance had been effected by the help of guncotton. In this case they retreated from the monastery into the fort as soon as the doors of the former were blown in, and from the fort into the open as soon as an entrance was made into the latter; they were then immediately shot down by the maxims and mounted infantry, who were in readiness on that flank.

Between this fight and the capture of the Jong a new bridge was built across the river, about two miles below the Mission Post. The volume of water had increased considerably, and the river had now a somewhat formidable current; so a place was chosen where there were two subsidiary streams and the main one was narrow and deep. The latter had a span of 45′, and the longest timbers available were only 22′; the current was too swift for a crib pier to stand in it; so both sides had to be cantilevered out until only a 20′ span was left. This was a matter of some difficulty as only 12′ timbers were available for the cantilevers, and only about 2½′ was gained by each layer. However, by continual anchoring and the use of very large stones, the structures were made very solid; and, as a precaution, tension ties were added, passing over a frame 8′ high in the clear, the ties being made of 6 strands of 14 B.W.G. tripping wire (see *Photo*).

CAPTURE OF GYANTSE JONG, 6TH JULY, 1904.

Three columns were told off for an assault on the Jong on the night of the 5th—6th July, all under command of Lieut.-Colonel Campbell, D.S.O., 40th Pathans.

The plan was that the three columns, with objectives as shewn in *Plate* I., *Fig.* 3, should emerge from behind Palla Post about 3 a.m., surprise the enemy, and obtain a lodgment in the town at the foot of the Jong by dawn. In order to do this it was necessary to take the Chinese house—a very strongly fortified double-storied building with a high courtyard wall in front, barred by a very strong entrance gate.

With each column as explosive party was a detachment of 12 Sappers under an R.E. Officer, explosives being also carried by the infantry. Each column was composed of two companies. The centre column in addition had one 7-pr. gun.

The left column gained its objective with slight opposition; but the centre and right ones were discovered by the enemy when 200 yards or more away from the Town, and a heavy direct and cross fire was opened on them. Seeing that the Chinese house could not now be

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taken by surprise, the centre and right columns effected a lodgment in garden (3), where they had an uncomfortable time, as there was no back wall and therefore very little cover from the close fire of the enemy. However, just as dawn was breaking, the 7-pr. got a couple of double shell on to the roof of the Chinese house, and, while the garrison were temporarily demoralized by this, the Sappers took the opportunity to blow in the courtyard gate; the house was then stormed, and the enemy quickly vacated the rest of the town. A heavy fire was kept up from the Jong while these operations were in progress, but after the Town was taken the greater part of the enemy left the Jong also. The Sappers were employed till noon in making a covered way (by breaking through the walls of houses) through the town, to connect the various pickets which had been posted. After this, the 10-pr. guns shelled the curtain wall, making the breach marked **X**; and this was most gallantly stormed by the 8th Gurkhas at 3 p.m. All further resistance ceased soon afterwards.

CROSSING THE BRAHMAPUTRA.

CHAKSAM FERRY.

On the way to Lhasa the Brahmaputra was crossed at Chaksam. The stores available were :—Four Berthon boats with superstructure for two rafts; two Thibetan ferry boats, shaped like large oblong boxes and capable of carrying 50 armed men or 22 mules at a time; a few Thibetan skin boats, capable of carrying 1,600 lbs. of stores or 10 armed men; also 200 yds. of 1″ steel cable and one traveller, and about 640 lbs. of 2″ and 1½″ manilla rope besides the ordinary equipment ropes (*Plate* II., *Figs.* 1 and 2).

Round Rock **A**, owing to the confluence of the two streams, the force of the current was terrific, and large whirlpools suddenly formed. These latter were a source of great danger to the Berthon boats, in one of which Major Bretherton (Chief Transport Officer) was drowned.

The crossing was commenced at mid-day on the 25th July, by rowing only, the Berthon boats being made up into rafts. This method was very slow, as the big ferry boats were occasionally unable to make the opposite shore; when this occurred they were carried beyond the island, and had to be towed up for nearly 1½ miles along the north bank.

On the 26th several efforts were made to get a line across, but all failed owing to the tremendous force of the current; the boats were therefore rowed over as before. The river having risen during the night, many boats were carried down stream, and by the end of the day only 14 boatloads had been put over in twelve hours of unremitting work. After the accident in which Major Bretherton lost his life, the Berthon rafts were given up and single boats used;

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these were found to be much more economical in time than the rafts, and also less dangerous.

In the early morning of the 27th a line was got across in the following manner at the third attempt :—Two of the Berthon boats were anchored out as far as possible from either bank, and connected by a line ; the two other boats then came out from opposite shores, bringing lines ; on approaching the anchored boats, they threw the ends of the shore lines to their occupants, who joined up with their own connecting line.

Having got the line across, the 1″ cable was hauled over and made fast to the top of rock **A**, which was about 20′ above the water ; the other end was passed over a trestle 10′ high at **B** and fixed to an anchorage. For the passage of every big boat, one end of a 2″ manilla rope was sent across from **B** to **A**, the other end being held on the shore at **B** by 60 coolies ; the end at **A** was then fixed to the boat, which was then swung and pulled across with the aid of the traveller on the cable. The rate of crossing by this contrivance was at once increased to 40 boatloads a day ; and the passage of the whole force—3,500 men, 3,500 animals, and 800,000 lbs. of stores—was completed in 5½ days.

PARTE FERRY.

On the return march of the Mission after the treaty had been signed in Lhasa, the half-coy. was allowed to go ahead to the Brahmaputra with one company of Gurkhas and 300 of Capt. Ross's coolie corps in order to prepare for the re-crossing of the force.

On arrival at Chaksam, it was found that some wire rope and other stores, which had been urgently indented for from India, had just arrived ; this was very fortunate, as, except the wire rope and traveller, none of the stores used on the outward journey were trustworthy after continual use at the ferry for six weeks.

The stores now available were therefore :—One 1½″ steel cable, 250 yards long, with traveller (this latter was, however, too heavy to be of any use, as it weighed over 80 lbs.) ; one 1″ steel cable, 170 yards long (30 yards had been broken off), with traveller ; 320 lbs. each of 2″ and 1½″ manilla rope ; 320 lbs. spikes and nails ; 320 lbs. plain wire ; remainder of rope, blocks, etc., in equipment ; boats as before.

A new and better ferry than Chaksam had been discovered at Parte, 11 miles up the river, so it was decided to move there by river with all boats, stores, etc., towing the big ferry boats. This proved a difficult and at times dangerous business, as the river ran very swiftly round the points, and the big boats leaked badly ; the latter defect was remedied by cutting up a couple of Thibetan skin boats and nailing the leather over and around the bows of the others ; and,

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after many minor accidents, the boats arrived at Parte safely on the third day.

It was at once decided to make *two* ferries; one at **AB**, span 105 yards; the other at **EF**, distance from bank to bank 140 yards and 170 yards between points of support of wire rope (*Plate* II., *Figs.* 3 to 7).

The 1½″ wire rope was stretched across the lower ferry, and the 1″ rope at the upper crossing; with such a big span as the latter, it would have been difficult to stretch the heavier rope taut enough to keep it out of the water. The light traveller was used at the lower ferry, and an ordinary single block at the upper.

Very large piers had to be made. They were constructed of gabions 5′ high, sunk so far out that their tops were level with the water; the gabions were filled with stones, and anchored back with wire, the space between them and the shore being filled up with stones.

In addition to the two swinging ferries, a service of Thibetan skin boats was arranged, working from **C** to **D**. These rendered excellent service, as each could take 10 armed men or 1,600 lbs. of stores at each trip.

Attempts were made to swim the mules over; but it was finally found quicker to take them across in the two ferry boats, which took 22 mules and kits (not loads) at a time. Three Thibetan skin boats, tied behind each ferry boat, took stores, kits, etc.; and a few mules were swum behind the rear skin boat at each trip.

The lower ferry, **AB**, was easily worked, the boats being pulled across by parties of 40 men. The distance was only 105 yards, and the stream was sluggish and deep. One end of a 150-yard 2″ manilla rope was made fast permanently to the bow of the ferry boat, and the free, or towing end, was attached to the traveller and pulled across the river by the traveller wire; the towing party detached the 2″ rope and pulled it taut, and the boat was then partly swung, partly hauled, across. The instant the boat arrived at pier **B**, the free end was again attached to the traveller and hauled over to **A**, and so on. We found that the rope parties never had to keep the boats waiting, the rope was always ready to pull before the boat had finished loading or unloading.

One difficulty was experienced (*Fig.* 6). Owing to the force of the current, it was impossible to undo the free end of the towing rope from the traveller on arrival, so a stopper rope was employed; on arrival, the end of the stopper rope was undone, and pulled taut until the towing rope was loose enough to be unfastened.

Five boatloads could be passed every hour, if the boats could be loaded and unloaded quickly enough; but generally the rate worked out at about 3½ boatloads per hour.

The arrangements at the upper ferry were rather more complicated,

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and were far more difficult to work owing to the great span and also to the fact that there was a very fierce current at the spot. Here *two* towing ropes had to be employed, and the free ends, when sent across, were attached to the bows of the boat, one rope for each side of the river. When the boat was at rest at pier "*d*," being loaded, the free end of one towing rope was attached to the block at **F**, hauled across and tied to the bow of the boat, its other end being held by 50 coolies on the bank at **F**. As the boat left pier "*d*" to be swung across, the free end of the second towing rope was attached to the block at **E**, and hauled across to **F** so as to be ready to be tied to the bow of the boat when unloaded at pier "*c*"; its other end was held by 50 coolies on the bank at **E**. The same procedure was followed when the boat was swung back. So a boat was always being swung across by one towing rope, while at the same time the free end of the other rope was being sent over on the block to swing the boat back.

Wire ropes, of eight strands of 14 B.W.G. each, were used as towing ropes, as it was found that the force of the water was so great that 2″ manilla ropes could not be hauled across at all. Stopper ropes were employed as at the lower ferry.

The working parties were as follows :—

At **A.**—Swinging party, 40 coolies, also worked stopper rope; traveller wire, an equipment mule. At **B.**—Swinging party, 40 sepoys, also worked stopper rope; traveller wire, 12 sepoys. At **E.**—Swinging party, 5 coolies; stopper rope, 20 coolies; traveller wire, 15 sappers. At **F.**—Swinging rope, 50 coolies; traveller wire, 20 coolies or sepoys; stopper rope, 20 coolies or sepoys. All these parties were supervised by a Sapper N.C.O. There were also numerous small parties to place gangways, secure and loose boats, etc.

A regular average of 3½ boatloads an hour was sent across the upper ferry.

The force began its passage at 11 a.m. on the 27th September; and, working till late on 27th and 28th, the whole were across in a little over 48 hours with no serious accident or hitch of any kind.

The march back to India was devoid of any engineering work of importance. The Chinese wall at Yatung had to be destroyed. The wall was 20′ high and 24′ thick. Thirty yards of it, and a very large and massive gateway, were destroyed with 180 lbs. of guncotton, fired electrically (see *Photos*).

Gyantse was reached on October 6th, and Chumbi on the 18th. Here the other half-company rejoined the Lhasa party, and the whole marched for Siliguri on the 25th, reaching that place on November 3rd and Roorkee on the 7th, after an absence of a year all but one week. The health of the Company was extraordinarily good throughout the campaign.

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ARMY RAILWAY ORGANIZATION.

By Capt. L. E. Hopkins, R.E.

THE following is written without any idea, beyond what I know by hearsay and observation, of what may or may not be the official policy in England or India. It is merely a study of the question, made to fill up many days of inaction during the frequent blizzards in Baluchistan of January and February. Many points are no doubt not new, but the analysis of the conditions of the problem, and the scheme as a whole, especially the non-military nature and the organisation of the Railway Corps for India, and many other minor points have perhaps new features. If any of those who took part in the stupendous railway operations undertaken by the Corps in South Africa disagree with my conclusions, I think it will be because they wrongly apply the special conditions of that war on considering what peace railway organisation is required in furtherance of the essential objects for which the Home and Indian armies are maintained.

The increase in the size of modern armies in civilised warfare has made it impossible to provide for their requirements over a long line of communications without a railway. It is not a question of money: it is simply that it cannot be done with animal transport. Our former expeditions, into Afghanistan for instance, were on a very small scale; and the troops were able to live to a great extent on the country, where an army of 150,000 men would be able to find nothing. In less ambitious wars, the advance to Khartoum in 1898 has provided an illustration of how much cheaper it is to advance with a railway and, in the case of pacification of a new country, how much more conducive to success. In South Africa, and again in China, it became necessary to take over and work long lengths of existing railway in a hurry, and attention was thus drawn to the question of providing previously organised railway labour for such emergencies.

The problems with which we have to deal are the repair of railways captured or recaptured from an enemy and partially destroyed by him, and the working of them; the construction and working of new lines for the use of an army in the field; and the construction and maintenance of fortress railways in peace, and of siege railways, field railways and railways in prepared defensive positions during war.

To take the last of these problems first, we are at once confronted with the question of narrow gauge lines, which have somehow become earmarked for railways in fortress and field. The adoption of the

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narrow gauge is usually justified by its adaptability to steep grades and sharp curves. The permanent way and rolling stock are no doubt suitable for very sharp curves, but the light locomotives suited to light military permanent way are quite useless on any grade steeper than $\frac{1}{100}$ and not much use at that. We have here (at Nishpa, Kelat) an ordinary four-coupled military light 2′ 6″ gauge locomotive, which was intended for use in pushing small skips of spoil in or out of the tunnel headings; and though the steepest grade was only $\frac{1}{62}$, and the road very good and laid with 41¼-lb. rails, it was found much easier to push the skips in and out by hand. I think we had the engine in steam twice only, and she is now locally known as the "coffee pot." Broad gauge locomotives and rolling stock with 14 ft. wheel base will work over 400-foot curves without any difficulty, as I know from experience; and they can of course negotiate heavy grades up to $\frac{1}{25}$ far better than light locomotives.

It is also supposed that a narrow gauge line is quicker to platelay. But as speed in platelaying depends on supply of permanent-way material, not on weight of rail, and as the supply of that material must depend on "coffee pot" locomotives working on heavy grades, it may be admitted at once that there is not likely to be much advantage in the long run for the narrow gauge. It would tax the resources of a broad gauge single line, with grades not steeper than $\frac{1}{50}$, to supply the wants of an army of 150,000 men in the field, which would probably amount to from 2,000 to 3,000 tons a day. Now it is said that a light 2′ 6″ locomotive can draw 30 tons net over $\frac{1}{40}$ grades; I doubt it, but for the sake of argument, 30 tons at an average speed of 8 miles an hour including stops, and with crossings four miles apart, gives one train per hour each way, or say 16 trains a day each way; and the total freight delivered at railhead will be 16 × 30 or 480 tons for single-engine trains and 1,440 tons for treble-engine trains, which, though a very sanguine estimate, is a long way short of 3,000 tons. A light narrow gauge locomotive on a line laid on ordinary country roads, with possible grades of $\frac{1}{15}$, over light rails hastily chucked down anyhow, would certainly not pull more than 10 tons.

The Germans think that they will be able to use their light narrow gauge material on such level highways as are to be found in the plains of Germany. In my opinion they are, as usual, backing theory too heavily; and they take no account of the utter unreliability of light rails and locomotives and stock, the narrow margin of power, the fact that a hastily made line has very inferior carrying capacity, that couplings smash and axles break, and that the light trucks and engines derail very easily. Narrow gauge railways are meant for such jobs as running about Woolwich Arsenal and big engineering works, where grades are easy and sharp curves are essential; but under ordinary circumstances they cannot compete with equally well-run

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broad gauge lines, and when it is a question of using native oriental labour, the difficulty of maintaining narrow gauge lines and locomotives in the high state of efficiency necessary to make the most of them is a very great disadvantage.

Permanent fortress lines should always be broad gauge. Field railways on the narrow gauge are no better than animal transport and are only justifiable where grades are known to be dead flat. The Germans have sunk money in the purchase of narrow gauge material for war purposes; but they are not infallible, and I think the money would be better employed elsewhere, if for no other reason than that the multiplication of types of permanent-way material, locomotives and rolling stock is undesirable and prohibitive. The only thing one can say in favour of light narrow gauge locomotives is that they do not get sore backs; but then a mule generally "gets there" somehow, and a "coffee pot" as often as not will not arrive for some days.

The speed of trains on narrow gauge lines is another very serious consideration. Although on heavy grades there would not be much difference, on easy grades narrow gauge light lines would not ordinarily stand a speed of over 10 miles an hour, where a broad gauge line under similar conditions of track might bear a speed of 25 to 30 miles an hour.

Commercially speaking narrow gauge railways have sometimes been made a moderate success, but only with heavy 40-lb. rails and heavy 25 to 30-ton locomotives, which of course alters the case entirely. As a matter of fact the only successful lines have been those with easy grades and curves. In nearly all cases rates charged are double and treble those in force on broad gauge lines. Working expenses are high, and the cost of hauling a ton one mile is about treble the cost on broad gauge lines. Of Indian lines the Barsi 2′ 6″ gauge railway has $\frac{1}{100}$ grades and not much of that and 600-foot curves, and its working expenses are 60 per cent. of gross receipts. The Darjeeling-Himalayan, with 20 miles of mountain line on $\frac{1}{23}$ grades and 60-foot curves on a 2′ 0″ foot gauge, pays its dividends largely out of a heavy rice traffic on the 12 miles of line in the plains and by charging rates ten times as high as those in force on broad gauge lines in the plains; by these means it is able to pay 8 or 9 per cent. on its capital, having been very economically constructed along an existing cart road. The Kalka-Simla railway was no doubt made possible by the adoption of the 2′ 6″ gauge with its sharp curves, but a simple arithmetical calculation will show that it can never possibly pay half the guaranteed interest. The Morvi line is successful on account of its easy grades and curves. In fact it is practically certain that, in most of the situations where narrow gauge lines have been successful, lines on the same gauge as, and worked and constructed by, the parent line, with old rails and engines and at slow speed, would have been at least equally successful.

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Narrow gauge railways for siege and field fortification purposes may perhaps be justified on the ground that they can be readily run in trenches in connection with hand-pushed trucks and that they generally require less cover for concealment and protection; but from every other point of view the broad gauge is first and the rest nowhere.

Having attempted to deal with the question of gauge, let us consider how Continental Powers meet the railway problem, and what are the conditions which have led up to the organisation of their railway troops. Continental armies possess numerous railway troops. Their position is this;--they expect to capture railways in foreign territory, where, on account of the whole population being actively or passively hostile, they would be compelled to provide every single man of the staff of the lines which they wished to work.

In the German army, railway troops form in peace time a brigade of three regiments, with an aggregate of nearly 4,000 men, under the command of a Major-General. These form a nucleus which is quadrupled for war by taking in men from the reserves who in peace time are civil employés on the State Railways. They include traffic and construction companies; and it is even considered necessary, for the reasons above stated, to provide large gangs of labourers for loading and unloading and work of a similar nature. In peace time the railway regiments work the Berlin-Juteborg Railway, 27 miles long, which in war time would be worked by their depôt companies. In war it is their duty to put in order railways captured from the enemy, and to work them until they can be handed over to the above-mentioned traffic detachments called out from among the State Railway employés.

France by contrast has only one regiment of railway troops, of eight companies. Volunteer railway detachments, enrolled from among the employés of the principal railway companies, are relied upon; these are civilians, and are exempt from military service. There are six of these detachments, each totalling about 1,300 men, and they are capable on mobilisation of taking over the entire working and maintenance of 1,600 miles of double-line railway.

The Russian army has four regular railway battalions, two employed in working the Trans-Caspian lines and one on the Central Asian Railways. They are sub-divided into 17 engineer and 27 traffic companies.

Of these three systems the German seems to be the best organisation on paper (assuming the figures in the paper on "Engineers and their Duties" in Vol. XXV., 1899, of the *R.E. Professional Papers* to be still correct). But the 4,000 men on the peace establishment cannot possibly get much training on the 27 miles of the Berlin-Juteborg line; and to an Englishman it would seem unnecessary to

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militarise the men they take in from the staff of the State Railways. It would probably be better to follow the French idea of a small number of regular railway troops for service at the front, and to rely on previously organised but unmilitarised civilian labour to take over the working of captured railways.

The Russians have the largest number of regular railway troops; but those in Russia proper seem to have no training, and those in Trans-Caspia and Central Asia must be practically civilians, and it is not quite clear how they can be relieved of the duty of running the Trans-Caspian railways and put on military duty at the front. The Russians have not, or had not in 1899 (see *R.E. Professional Papers*, Vol. XXV., 1899), any organised civil railway detachments.

The Germans and French seem to know what they want, and the latter seem most likely to be able to meet their wants in war time. They both recognise that for working railways in a hostile European country they must have a complete staff ready. Their scheme does not provide for the rapid construction of long lengths of communication railways, and they do not require to provide for the construction of anything more than siege lines and temporary diversions of, at most, a dozen miles or so. The Russians on the other hand seem to be muddling along somehow in much the same way as the journalists seem to think that we do in England.

The question of what we in England want in the matter of military railway organisation depends on conditions very different from those sketched above. Our Army may be divided roughly into the Home* and the Indian armies. The duty of the Home Army is primarily the defence of England; and, to a certain extent, the defence of the Colonies and naval bases, which are however more under the charge of the Navy. In a secondary position there are such unforeseen affairs as the Boer Wars, the recovery of the Soudan, and the settlement of such countries as Egypt, the strategical position of which forces them upon our notice. The essential duty of the Home Army is however the defence of England. There is no question of invasion of European countries and capture of railways in hostile territory; there is a remote contingency of invasion of countries adjacent to our Colonies, and of "Striking Force" expeditions on the continent of Europe; but there is no call to provide railway organization for these affairs.

All that we require then in the way of railway troops is a sufficiency of companies for running fortress railways in England and at the Colonial military and naval bases. Railway troops may also be required for such work as was necessary in South Africa, in China, and in Egypt in 1882. These are however really unimportant affairs;

* The term Home Army is intended to mean the force charged with the defence of England and the Colonies.

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they do not call for expenditure on elaborate preparations. They are not essential. It is quite sufficient for the above-mentioned duties to provide 3 or 4 railway companies of the existing type, each capable of repairing and working 25 miles of line and of undertaking siege and fortress railways.

For the defence of England itself, however, there are some other railway preparations which are essential. The civilian management of the great English railways should in case of invasion come under the orders of the Commander-in-Chief. The existing management can best carry on the railway work after an invasion, whether it is a question of repairing lines destroyed by invaders or of working military traffic. The Managers should however be in touch with the War Office in peace time, and they should be informed what is expected of their railways in the way of troop trains on mobilisation. Details of defence of lines, and of the co-operation of railway and military officials in war time through the medium of Railway Staff Officers, should be worked out and settled in such a way that there will be no hitch at the critical moment. If it is considered necessary to have military control over a large amount of labour for construction and maintenance, the Railway Volunteer Staff Corps provides an organisation ready to hand and requiring little elaboration.

The question remains whether military railway troops should be kept up for such chance occasions as a Suakim-Berber Railway or Soudan Military Railway. I do not think anyone would recommend such a proposal, taking into account the following considerations, together with the above-mentioned fact that such things are outside the real object for which the Home army exists. Military labour, being in the nature of forced labour, can never compare in efficiency with voluntary civil labour. Civil labour can always be obtained by paying for it, and it is cheaper to pay a high price for a special work and have it well done than to keep up continual expenditure on military railway troops and perhaps get the work not so well done in the end. For really large railway enterprises it would be out of the question to keep up sufficient railway troops to be anything more than a mere drop in the ocean of labour required. The Suakim-Berber Railway did not fail for lack of military railway troops, but on account of the difficulty of the undertaking and the hostility of the natives. It is better to let the military work be done by soldiers and the civil work by civilians; if the first is done properly, there will be no difficulty about the other.

In short for the Home army there is no justification for keeping up more railway troops than 3 or 4 railway companies of the present type. Their *personnel* should be soldiers first and railway men afterwards. They should largely confine their duties to the maintenance and construction of siege and fortress railways, and should work out the details of such affairs in conjunction with the fortification and

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artillery branches. They should all be skilled men ; it is waste of money to keep more labourers than is absolutely necessary. The officers of railway companies might divide the duties of Management, Traffic, Engineering and Locomotive Work, and specialize themselves in one or other of these subjects as far as possible with the means at their disposal. The non-commissioned officers should divide the duties of Loco. Foremen, Station Masters, Permanent Way Inspectors, Carriage Examiners, Vacuum Brake Inspectors, Engineer Overseers, and Storekeepers. The men would be enlisted as Drivers, Shunters, Foremen, Platelayers, Signallers, Clerks, Masons, Smiths, Carpenters, Fitters and Gangers. The railway worked in peace time should have some definite purpose, should run from somewhere to somewhere instead of having both ends in the air ; there should be a regular service of trains over it and public traffic attracted. A depôt should run the line when the companies are mobilised.

The organisation should be on the idea that the companies, on arrival at their siege or other work, should make use of local labour as platelayers, porters, shunters, cleaners, coal heavers, and all the unskilled jobs. In nearly all countries in which our army is likely to operate such local labour will be procurable ; in Egypt, South Africa, China, anywhere almost outside of Europe and the United States, there will be no difficulty about it. With this idea there will be no occasion to train men to lay rails quickly. Laying permanent way can be very quickly learnt by intelligent men ; and its speed depends mostly on the state of the rolling stock, the supply of material, the number of labourers employed, and the organisation for feeding them and giving them sleep.

The Loco. men must be carefully trained in driving, cleaning and repairing engines and rolling stock under all conditions of bad water, bad fuel, heat, cold, snow, defective valves and defective brake power on heavy grades. There is as much difference between driving an engine and being a first-class driver, as between riding a horse and being a good horse master. Then there are such things as derailments ; and re-railing a 60-ton engine cannot be done off hand by anyone. Foremen Platelayers require some slight experience to keep a line in good order. Traffic work is mainly a question of common sense and discipline ; but, even so, Station Masters and Signallers require practice and especially a knowledge of principles as laid down in any Railway General Rules. Though engineering is, as an old platelayer said, largely a matter of brute force and stupidity, still there are such things as laying points and crossings, handling high explosives and riveting girders, which cannot be properly carried out without some practical experience.

I have no information on the subject of the existing railway companies except such as is given in *War Establishments* and the *Equipment Tables*. The omission from the latter of "Safety

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Fuze" (unless I am mistaken) and the provision of 100 yards of "Instantaneous Fuze," which is not a widely-used article and not a necessity, seems curious. Electric exploders and all their paraphernalia might well be omitted as unnecessary and too cumbersome for war service. To the equipment might perhaps be added re-railing ramps, suitable for rails of from 60 to 80 lbs. per yard, and drivers should be taught how to use them ; I have seen a first-class European driver trying to re-rail his engine with his ramps upside down and wrong way round. The three-inch (?) hemp hawsers, which appear to be the largest provided, would not be of much use for re-erection of damaged girders.

We can now consider the requirements of India. The duties of the Indian army are the defence of the North-West Frontier—the North-East Frontier need not be considered—and ultimately perhaps the maintenance of British Power in India itself. It is however more usual to consider British power maintained by law and police, and the army retained for external defence. This at least is the view of the "British Public" as laid down in the *Spectator*, founded no doubt on the recent redistribution of the Army in India.

The whole of the railways in India are worked by native labour, and in the event of serious internal disturbances the movement of troops might be at the mercy of the natives. If then we are to apprehend any serious, widely-diffused and well-organised revolution in the country, we are bound to make arrangements for the supply from England of a large number of military railway troops ; for it would be out of the question to expect civil labour, scattered over the country at the mercy of every rebel and unorganised for resistance, to carry out the work required. But conjecture fails to say what would happen if we were reduced to such a state of affairs in India. The fact is that though we hold India to a certain extent by force of arms, we mainly hold it by force of good government ; when that government shall have become so distasteful to the people as to bring about a general rising, which it has also been unable to foresee and check, it will be time we cleared out of India and that quickly. We may therefore dismiss the possibility of having to work the Indian railways by military forces in time of internal disturbance.

Then there is the question of sending railway troops out of India to work railways captured in foreign territory, as happened in China. Such work is entirely outside of the legitimate purpose of the Indian army. It was no doubt inconvenient that no railway troops were available in China, and this appeared much more so from the fact that the other Powers all had railway technical troops in their pockets so to speak. But it is probable that, if they had been pressed, the Railway Department of the Government of India could have supplied *personnel* and *matériel* without the least difficulty.

The main purpose for which the Indian army has to be maintained

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is the defence of the North-West Frontier. In the event of war it may be necessary to advance the defensive frontier some 400 miles more or less beyond the present political frontier, and it is therefore essential to provide for the very rapid construction of railways in support of that advance. As a maximum to be aimed at, it should be possible to push forward 200 miles of line simultaneously into both Northern and Southern Afghanistan within twelve months. It is useless to conjecture what might or might not be the relative positions of the Indian and Russian armies at the moment of declaration of war and soon afterwards, what might be the position of Sistan, or which would be able to seize Herat first. But it may be assumed that, in the event of war and an advance into Afghanistan, we should either go there as allies or would, at least at first, only have to contend against Afghans. For this reason it seems unlikely that a force of more than 50,000 men would leave the Indian railhead at the commencement, such a force in fact as could be maintained in the field at a distance of 100 miles from railhead by means of animal transport alone and by relying largely on local supplies of grain, fodder and forage. That 100 miles across the frontier should be practically as quiet as the 100 miles on the Indian side; if not it is the business of the advance force to make it so; and until that is done there will be the greatest difficulty in making a railway. If the conditions make it necessary for convoys to have larger escorts than is required for mere watch and ward, it will be a difficult matter to construct a railway. I do not think it will make the smallest difference whether we use military labour or civilian labour with military escort; the work will not get done.

The conditions of the advance will remain the same until the main armies are within striking distance of each other, that is to say there will be an advance force of about 50,000 men on either side while the main armies advance with railheads. For of course the Russian advance will have to be made on a similar plan; and for this very reason it has come to be recognised that the fantastic ideas expressed by some Russian Generals, that India might be attacked by a vast horde of Cossacks working independently in imitation of the old days, are quite insupportable. Even if such an invasion were successful at first, it could never do any good in the long run, and without the support of a large army and railway the force would be simply annihilated. By the old methods of attack on India the attacking force annihilated in one decisive battle the feeble resistance they met, and then proceeded to settle down and make themselves comfortable; and there was no question of reinforcements for the defenders from their base on the sea, as would now be the case. Their case was always like that of the first invaders of India, the Saracens, who, on their arrival in Sind, received orders from the Khalifah Suliman at Bagdad to "sow and sweat wherever you may find yourselves on

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receipt of this mandate, for there will be no more Syria for you"; and in Sind their descendants have been ever since, and still form part of the nondescript population of that country and Baluchistan.

Provided that the enormous quantity of necessary stores have been prepared beforehand, some 20,000 labourers and a large administrative staff will be required to construct these lines-of-communication railways as rapidly as possible. To work them a further provision of labour will be necessary. It is a question whether all this labour can and should be military or civilian.

The sole advantage of military labour for construction is that it is amenable to military discipline, that it is always ready, and has to go anywhere and do anything it is told. Another point put forward as an advantage is that it can defend itself and does not require escorts. This latter seems to be a misconception. In the first place the labour constructing the railway should, as pointed out above, be free from anything worse than the attacks of robbers or raiders, capable of repulse by small guards and local levies; if it is not, the railway will inevitably not progress. In the second place it means compromise, which though often expedient is usually unsatisfactory, and which in the present case is bound to fail. Whatever may be done in the way of soldiering and engineering compromise with English officers and men, it is certain that the native of India must be either wholly a civilian or wholly a soldier. There is a hard and fast line between the classes who enlist as soldiers and those who are labourers; and even if you enlist a labourer as a soldier, he will very soon suffer badly from swelled head and be quite useless as a workman. Of course there are exceptions, which, however, it would be invidious to specify, but as a general rule the soldier in Hindustan will not condescend to dirty his hands.

The disadvantages of the use of military labour are numerous. In the first place, there must be a large technical administrative constructional staff, either civil or Royal Engineers from civil employ, as well as subordinate civilians and artisans. At the same time the military labour regiments have their own officers, who are not necessarily technically trained and who, however excellent they may be as officers, are inevitably rather in the position of the fifth wheel to the coach; while the rank and file often would not co-operate with the subordinate technical staff, and would not coalesce with the civil labour of which a certain amount (mainly skilled) would be absolutely necessary. It is a matter of fact needing no apology that military labour does not do as much work as civil. The men are under military law, their work is done by order and they get their pay in any case. They must spend much of their time on military duties, and a proportion is wholly required for military duty, such as guards; and, generalising, where the coolie gets along somehow, the soldier, as someone has expressed it, requires "hot and cold water laid on."

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Technical railway troops, as distinct from regiments of labourers, must also be maintained if only military labour is to be employed; and I believe that to keep up a sufficient quantity of such troops to construct 400 miles of railway would be quite impossible. Moreover skilled labour cannot be enlisted in railway corps for the simple reason that the pay is not sufficient, and railway trades cannot be taught from a text book any more than tactics can be learnt without war experience. Supposing the pay to be raised sufficiently to attract skilled labour, there will be the greatest difficulty in keeping that labour supplied with work, as is the case now with sappers and miners, and the men will rapidly fall off in value.

Granted then that skilled labour cannot be militarised, what sort of organisation can be expected to work properly, in which regiments of military labourers are sandwiched among civilian artisans and a wholly civilian loco. and traffic staff? What sort of a maintenance gang is it that goes to work with a rifle in one hand and a pick or shovel in the other? Neither fish nor fowl. While using their rifles they are under the Officer Commanding Lines-of-Communications, and while shovelling they take orders from the Railway Officer; unless the Railway Officer and Officer Commanding Lines-of-Communications are combined in one. By arming maintenance gangs you make them liable to the duties and penalties of combatants, while the amount of protection you afford to the line is infinitesimal.

All these facts are pretty generally admitted as regards locomotive and traffic labour; but there seems to be an impression, on what grounds it is difficult to say, that engineering trades must be militarised.

The objections raised against civil labour for railway construction in war are that it is not amenable to military discipline and that it may not be forthcoming when required. To take the latter point first, I think it is merely a question of money so far as skilled labour is concerned; and if double rates have to be paid, there will still be a saving in actual cash compared with the expense of keeping up military labour doing nothing for years; and what is far more important the labour obtained will be efficient and the work will be well done. I will endeavour to show further on that the first objection can also be overcome. As regards unskilled coolie labour there is no question that thousands of Ghilzais, Hazaras and Pathans, many of whom have been on railway construction works in India and Burma, will flock to the works in Afghanistan. There is little question of patriotism among the most loyal of such races; they cannot afford it. The feeling of antagonism to white men is largely confined to the ruling classes and is a matter of self-interest; they are well off and do not wish to be interfered with and see their absolute independence turned into the semi-independence of our ruling princes in India. The highest bidder, and the bidding need not be very high, will get all the labour wanted in Afghanistan. The spending of large sums of money on

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local labour must moreover have the effect of improving local feeling towards the army and putting a stop to all petty hostility.

A civil organisation has a great advantage in being more elastic; it provides for men going away when they have had enough and being replaced by others, whereas military men have to work to order; and everyone knows the difference between working to order and working on one's own initiative.

There is one other argument put forward for military labour. It is thought that platelaying is a highly technical matter, requiring trained men if the work is to progress quickly, and that therefore troops trained to the work must be kept ready. This again is a misconception. The art of platelaying can be picked up in a week by any given gang of men, provided the supervising staff know their business; and although no doubt speed of platelaying ultimately depends on the rate of linking up the joints, the utmost possible limit is never approached in practice. Progress of platelaying really depends on the rate at which material can be supplied and the capacity for organisation of the engineer in charge.

The above remarks apply mainly to construction. For maintenance it can be shown that India has no need of railway technical troops. In European armies the *rôle* of railway companies is to patch up lines, immediately behind an advancing army, captured or re-captured from the enemy, and possibly to run a few trains at the front. Also they may be required to lay diversions round fortresses; and in no case can they expect to get labour locally, except by force. Now there is no analogy between these conditions and the conditions in India, and because European nations have railway troops there is no reason why we should in India. It is a far cry from Quetta to Russian-Central Asian Railways, and by the time we arrived there (supposing there were any motive for going) we should have had time enough if necessary to organise railway troops. But as a fact railway troops would not be required. We should make use of local labour, which there need be no question would be readily obtainable. The Central Asian people have no strong tie or loyalty to their present rulers, and in any case Oriental nations have not that strong sense of patriotism which makes it so difficult for invaders in Europe to obtain local labour. For this fact we have a proof in the Russian advance on Constantinople in 1878, when they captured the Turkish Railway (Chemins de Fer Orientaux) and practically took over the existing staff to work it.

The question of the repair of lines re-captured from an enemy who may have penetrated into India is too remote a contingency to call for organisation in anticipation. The lines we construct in Afghanistan might be captured by and re-captured from an enemy; but by that time a railway repair corps, on the model of the Railway Pioneer Regiment in the South African War, will have been readily

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organised on a semi-military basis out of the seasoned construction staff.

From the above consideration I am led to the conclusion that we require in India a Railway Corps on the lines of the French civilian detachments. We must have some organisation which will ensure the supply of the necessary civilian labour when the time arrives. The corps should not be military, but on mobilisation it should become subject to military law. By enrolling only the best men, and by granting certain civil advantages, a member should obtain "*izzat*" or honour by joining the corps. The head of the corps would be the Manager of the North-Western Railway (Lahore), who would in peace time have a Royal Engineer officer as staff officer in charge of the corps organisation, in correspondence with the Quartermaster-General and the local heads of detachments. Government servants of the Railway Department, who are civilians and not bound to serve beyond the frontier, might be expected to join the corps without hesitation if they were assured that on mobilisation they would become entitled to an allowance equal to 33 per cent. of their salary and to double travelling allowances. Military Engineer officers would be detailed for duty with the corps, and on mobilisation would be entitled to whatever allowances are sanctioned under existing rules.

Subordinate (civilian) members of the corps might be induced to join by means of a nominal retaining fee, for administrative purposes, of about 10 per cent. of the average wage of their trade or profession, not exceeding Rs.30 per mensem; by certain civil privileges, such as exemption from the provisions of the Army Act, reduced fares when travelling by rail, exemption from service on juries; by commissions or certificates of membership of the corps, carrying titles; by deferred pay and liberal pay on mobilisation; by wound and disease pensions and life insurance; and by a scale of pensions for one, two or three years approved active service or permanent employment on a State Railway. There might also be a gratuity payable after five, ten, fifteen or twenty years enrolment in the corps. The agreement would be annual, terminable by either side annually; and the local heads of detachments would be required to certify to the efficiency, suitability and fitness for active service, morally and physically, at each annual renewal of the contract. The staff officer at headquarters would inspect some of the local corps every year, and further certify to their efficiency. The penalty for not joining on mobilisation would be the penalty for desertion under the Army Act. The deferred pay on joining would be an inducement to join when called out on service; the civil rights, etc., are an inducement to enrol; and pension, pay, etc., an insurance against desertion and discontent while on service.

The corps might be graded:—Officers as 1st, 2nd and 3rd class; overseers, supervisors, foremen, etc. as Conductors or *Jemadars*; and the workmen as Pioneers. The money paid to members in peace

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time should be merely a nominal sum, or the men would live on it and the existing railway staff to which many of them would belong would be disorganised. The advantages of belonging to the corps in peace should be mainly honorary, or should at least have no cash value. There should be no medical examination before enrolment; but nomination to the corps should be made solely by responsible officers of State or other Railways, themselves officers of the corps, who on active service would have to make use of the services of the men they nominate. The officers might be distributed all over India on various railways; if all were on the North-Western Railway, that line would be denuded of staff on mobilisation. Still a large proportion might be taken from the North-Western without disturbing its organisation.

There should be no drill or any suggestion of militarisation, which civilians as a rule I believe strongly dislike and mistrust. The strength of the corps might be about 3,500, possibly less.

The organisation would be on the following lines. The ranks of the officers would be filled up with Managers, Engineers, Traffic Officers, Loco. Officers, Storekeepers and Account Officers of varying degrees of seniority, and big contractors. The Conductor or *Jemadar* rank would comprise Loco. Foremen, Station Masters, Senior Drivers, Clerks of all branches, Overseers, Sub-Engineers, Permanent Way Inspectors, Traffic Inspectors, etc., and contractors. The Pioneer ranks would be filled up with Sub-Overseers, Guards, Drivers, a few Firemen, Gangers, Shunters, Fitters, Masons, Carpenters, Bricklayers, Smiths, and possibly some others. Contractors have been included because they are the men who have command of labour and also experience with the petty details of engineering. Although an engineer is perfectly able to carry out work by daily labour, it is not usually considered an economical use of his services; one would as soon expect him to habitually do his own cooking instead of employing servants for the purpose. We do not want to enrol labourers for earthwork or platelaying or maintenance. Pathan labour will be available locally, as pointed out above; and if necessary Contractors, Engineers and Overseers and Permanent Way Inspectors, who are invariably able to put their hands on any quantity of labour, will be able to arrange for it when ordered on duty. Only mates or maintenance gangers need be enrolled, and these might bring men with them if necessary; but the latter need not be enrolled. Maintenance of way depends on the mate or ganger; provided the ganger is skilled there is no difficulty. There is no skill required in tamping with a pick or using a lever or tightening bolts; and in fact all new lines are at first maintained by inexperienced coolies in charge of more or less experienced mates. In the same way Survey *khelassies* are manufactured in a week out of the most stupid and thick-headed Pathans.

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The headquarters of the corps would be at Lahore where the Manager and his Staff Officer and the Chief Engineer reside. The detachments might be distributed as in the following table :—

(1). *North-Western Railway.*	(2). *Oudh and Rohilkhand Railway.*
Manager. Staff Officer. Engineer-in-Chief.	Traffic Superintendent. Engineer-in-Chief.
Two Engineering Detachments as in column 5.	Two Engineering Detachments as in column 5.
One Store Section (Permanent), viz. :— 1 Chief Storekeeper. 2 Sub-Storekeepers. 10 Clerks. 20 Watchmen and Messengers, etc.	One Accounts Section, viz. :— 3 Examiners of Accounts. 8 Accountants. 40 Clerks.

(3). *Great Indian Peninsular and East Indian Railways.*	(4). *Madras Railway and Bombay, Baroda and Central Indian Railway.*
One Traffic Detachment each.	One Locomotive Detachment each.
1 Dist. Traffic Supt. 1 Traffic Inspector. 10 Station Masters. 10 Shunting Jemadars. 10 Signallers. 20 Guards. 3 Clerks.	1 Dist. Loco. Supt. 2 Foremen. 25 Drivers. 25 Firemen and Cleaners. 1 Carriage Examiner. 1 Vacuum Brake Inspector. 10 Fitters. 5 Carpenters. 10 Smiths. 3 Clerks.

(5). *State Railways under Construction and Survey.*
Four Engineering Detachments.
1 Executive Engineer. 3 Assistant Engineers. 10 Clerks 10 Sub-Engineers and Overseers. 10 Sub-Overseers and Timekeepers. 30 Carpenters and Smiths. 10 Masons and Bricklayers. 30 Permanent Way Inspectors and Assistant Do. 20 Gangers. 10 Contractors. 100 Contractors' Men.

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The cost of the corps in peace time would be about Rs.140,000 a year as against Rs.240,000, the cost of a native Pioneer Regiment. Rs.140,000 represents a charge of $\frac{1}{3}$ per cent. per annum on the cost of constructing economically the 400 miles of line for which purpose the corps is to be maintained. So that, if it should not become necessary to construct the lines until the lapse of half a century, the cost of maintaining the corps would add only about 17 per cent. to the cost of the lines; while it may be supposed that to construct them without some such organised corps would mean an expenditure of at least 50 per cent. above their ordinary economical cost. The 17 per cent. would be paid out of revenue, whereas the 50 per cent. would come out of capital; so one might prove that, with interest at 4 per cent., the corps would be actually making about Rs.660,000, instead of costing Rs.140,000, per annum. At any rate if there is real need for the corps there can be no objection on the score of cost.

I have attempted to deal with the railway requirements of the Home army, to settle the narrow gauge question, and to make it clear that for India there is only one *raison d'être* for a railway organisation for active service, viz.:—The construction of railways across the North-West Frontier to follow an advancing army. The conditions of this advance and construction can be laid down with almost mathematical accuracy, and I have tried to sketch an organisation, which will serve those conditions, in an Indian Railway Corps.

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*THE SIBERIAN RAILWAY IN WAR.**

By CAPT. C. E. VICKERS, R.E.

CAPT. VON TOEPFER'S paper is the first connected account, of any use for military purposes, which the present writer has seen of the working of this great military railway system, the main connecting link between the Russian armies engaged in the present conflict and their sources of supply. It is unnecessary to dwell upon its vital importance to the Russian armies engaged; but it seems certainly worth while to endeavour to summarise the principal features of the methods upon which it is being worked. Technical information in English bearing on the subject is not very easy to obtain, and is apt to be rather vague, but I have endeavoured to gather additional particulars from various sources and to set them down in some sort of order.

The whole question of the working of railways under war conditions is full of interest, more particularly to an army like ours which may be concerned with operations in so many different parts of the world, and discussion on the subject is not lacking; but it must be confessed that people unacquainted with the practical management and working of Railways are apt to underrate the magnitude of the problems which arise in the direction of railway affairs under war conditions, and which would arise in England itself, should by any unhappy chance war ever penetrate to our shores.

It is of interest to perceive that almost from the inception of this Trans-Asian project military considerations have been practically paramount, though, as has been well pointed out, a Railway across an uncivilised country always has another and more pacific influence, as constituting a channel of trade, a rapid way of communication, and a means of quelling disturbances by the transport of troops to threatened places.

The Siberian railway has not worked perfectly; nothing does under conditions of extreme pressure. But, having in view the difficulties which have been overcome, it is but due to acknowledge the foresight and grasp of those who conceived the plan, and the ability of those

(* With acknowledgments to the paper, by Capt. von Toepfer, Instructor at the Dantzig Military College, in the *Kriegstechnische Zeitschrift*, August 8th, 1904, and to sundry other publications. A translation of Capt. von Toepfer's paper was communicated by the Chief of the General Staff, W.O.).

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who organised such a vast system, which, all said and done, has shewn wonderfully few breakdowns, and has successfully performed its task so far in a way which must extort admiration. For the Russian armies, at least, have been kept going.

It will perhaps be convenient to allude first to physical features and equipment, then to consider the system of working, and finally to look at the results accomplished during the present war. Information on many points is lacking, but we must hope to learn more as time goes on.

THE LINE.

The ruling grades and curves do not appear to be really severe, although at places in Mid-Siberia six-coupled goods engines could only draw 24 loaded trucks owing to the sharp curves, which run up to 250 mètres radius. This is about 12½ chains, so that either the engine wheel base must be very long, or there must be other reasons. Certainly much of the line was at first not properly ballasted. On the Manchurian Railway the location seems to have been more advantageous; the minimum curve radius is generally not less than 425 mètres, with exceptional curves of 236 mètres. The ruling grade is 1½ per cent. in hilly country, while on the plains the ruling grade is 0·8 per cent., compensated to 0·6 per cent. on curves of 640 mètres.

Loco. depôts are naturally enough sited as far as possible at the foot of steep sections, so as to facilitate banking. Permanent way on the Manchurian line is laid with 67-lb. rails, and is well ballasted,* the formation being 18 ft. wide and the side slopes kept flat. The Siberian railway proper was originally "laid in a very careless and inefficient manner"; the original rails were 42 to 47 lbs. per yard, and too weak, for buckling and spreading used to be not uncommon occurrences. In the year 1898 £15,000,000 had to be provided for improving and re-laying up to Lake Baikal. The bridges are throughout substantially constructed, though on the Ussurian line, *i.e.*, towards Vladivostock, where for hundreds of miles no stone is to be found, timber was necessarily employed.

In constructing the Manchurian line the first necessity was to get the line joined up after some fashion, so that workmen, materials and provisions might be got through to carry on the permanent construction. All obstacles offered by the ground were therefore turned, temporary bridges and deviations used, and heavy gradients allowed so as to reduce earthwork. The Chingan tunnel, which is 2½ miles long, was avoided during construction by a 12½-mile deviation with three switchback reversing stations.

There are a number of large bridges on the Manchurian line, 14 of over 220 yards length, among them those over the Nonni,

* 18″ of top ballast appears to be allowed.

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Sungari (two), and Hung-Ho. The Sungari bridge, near Harbin, is 1,040 yards long. All these large bridges* have stone piers and girderwork superstructure. The culverts, etc., for water passage (flood openings, etc.) average 10 yards per kilomètre. Reinforced concrete has been used a good deal on the Manchurian Railway for decking culverts; the normal span used is 7 ft., the thickness 8¼ inches with rail reinforcement; and similar construction is employed up to 21 ft. span.

At the commencement of the war the break at Lake Baikal was undoubtedly the most serious obstacle to the working of through traffic. Even in summer time (and the lake is much subject to storms) each of the two transfer steamers could make but three crossings in 48 hours, each time conveying 27 trucks, *i.e.*, an average of 40 trucks per steamer per day; and although the vessels are constructed as icebreakers, traffic used to be entirely suspended (except what went over by sledge) for three months of the year, and absolutely stopped for about six weeks when the ice was not firm enough to carry sledge traffic.

It is evident, moreover, that at the beginning of the war the amount of rolling stock available on the Trans-Baikal section was quite inadequate to forward the traffic which could be got up to the lake, however perfect might be the arrangements organised for its transfer. There was therefore the greater urgency to get some sort of line through, in order that engines might be got to the other side. Up to 1903 the project of laying a line round the lake appears to have remained in abeyance, owing doubtless to the great cost involved; but as the political horizon darkened, and it became evident that however much the capacity of the Siberian line might be increased the net effect would be to pile up more traffic at the west side of the lake, it was forced upon the Russian ministry that the undertaking must be faced.

The Circum-Baikal line, Irkutsk to Myssowaja, some 162 miles, includes no less than 34 tunnels,† some as much as a kilomètre long; in all 6¼ miles of boring, 200 bridges and large culverts, while at other points it is largely built up by retaining walls. The cost was about £52,000 per mile, and the difficulties of rapid construction were very great. Irregularities on the part of the contractors in feeding their workmen caused strikes in several places. Carelessness, possibly culpable, caused a fire in one of the tunnels, so delaying boring; and positively wilful neglect in storing explosives endangered the lives of the workmen and progress of the work. The special train carrying

* Some of these big bridges were destroyed during the retirement and the Japanese are now taking traffic over by deviations.

† The tunnels are constructed for double line, but only one road was laid.

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the inspection committee, which was to take over a section was derailed between Tanchoi and Kultuk. In this we can feel some sympathy with the engineers, for newly laid lines are extraordinarily apt to derail a train or two before they settle down!

It was essential to get a line across the ice as soon as it would bear. On January 27th, 1904, the ferry steamers had made their last journey; and after a thickness of 1½ mètres of ice had been registered and experiments had been made with goods engines under steam, the laying of rails from Baikal to Tanchoi across the ice was begun on February 9th. There were special difficulties, however, apart from the extreme cold and storms, in the ice movements and cracks. Earthquake shocks occurred from time to time, causing an undulating movement of the whole of the ice, with such sudden violence as to break rails and fishbolts and to entirely destroy several lengths of line in places. But all these difficulties were overcome, and, by spreading the weight with extra long sleepers and, in some places, a second gridiron of beams, a sufficiently secure road was eventually obtained. Traffic was commenced on March 1st, *i.e.*, a laying rate of about 1⅓ miles per day was maintained. Engine power was not used, as one engine had gone through the ice at a trial. 600 men and 1,000 horses supplied the motive power, and between 1st and 26th March 65 engines, 25 carriages and 2,313 covered and open goods wagons were worked across.

To compare with a smaller undertaking of the same kind, one may recall the transfer of traffic across Bethulie Road bridge during the South African war (March—April, 1900). In this case trucks were separately pushed across by hand while the low-level deviation was under construction, the road bridge being not strong enough to carry engines and only able to bear loaded trucks singly.

It is seemingly on the Trans-Baikal section (between Tanchoi and Harbin) that the principal difficulties as regards fuel and water supply are experienced, and the latter question is very serious. Most of the rivers which have to provide water freeze down to the very bottom. A few feet below the ground surface almost along the whole line, but particularly in the Jablonowy Mountains, there is encountered a permanently frozen layer up to 44 ft. in thickness; and consequently, except in a few places such as Tachita, where artesian wells are satisfactory, the boring has to be sunk deep.

At first it was only possible to work six trains a day on this section; but after adding 11 new stations and additional lines at twelve others (so as to simplify crossing trains and avoid the tedious process of see-sawing), it was expected to increase the capacity of the line to about 9 trains a day by May, 1904, and more later on. The average train load appears to be about 35 vehicles, each of which will convey 40 men or 8 horses.

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MILITARY CONTROL.

The total length of the line of railway communication from the Russian frontier to Mukden is 3,882 miles, viz., the Siberian Section (west of Lake Baikal) 2,050 miles; the Circum-Baikal line, 162 miles; the Trans-Baikal railway (Myssowaja to Kaidalowo, and thence to the Chinese frontier, Mandshuria), 750 miles; the Manchurian Railway (to Mukden), 920 miles. There is also the Ussurian section, about 450 miles.*

Under peace conditions the Ministry of Communications, the Finance, and the State Departments are all interested in the control of the Railways; the Finance Department controls the Manchurian Railway through the Russo-Chinese Bank—but the Ministry of Communications is mainly concerned, and practically the traffic is directed by the Committee for Siberian Railways, which was formed about ten years since and sits under the presidency of the Emperor. The *Working* of each section is under the direction of its own *Line Manager*.

Of the Headquarter Staff at St. Petersburg the 1st department of the Administration of Military Communications deals with study of all means of communication, organisation of troop moves in peace time, etc., while the 2nd department deals with transport on mobilization and the working of the railways in connection therewith, line of communication organization, postal and telegraph services. In the various military districts also officers are specially appointed for dealing with the transport of troops under the department: these appear to be the intermediaries between the Commanders of Districts and the working staff of the railway.

Additional to this, however, on February 23rd, 1904, an "Executive Committee for the organization of Railway Transport to the Far East" was organised under the Chief of Military Communications at the Ministry of War. This Committee controls all railway transport on the Line of Communications and regulates war railway traffic. Again, on the staff of the Commander-in-Chief and under the Chief of Military Communications of the Army there has been constituted a Railway Department, which superintends and supplements as may be necessary all railways and waterways beyond Lake Baikal. This, in fact, is what we should know as the Director of Railways' department—or what, under the French system, is the department of Railways and Communications. The work of increasing the capacity for traffic of the whole of the Siberian Railway (up to the Chinese frontier) is placed under the Minister of Communications.

* The Ussurian section appears to include a branch line to the coal mines at Soutchen (138 kilom.). The junction is about 30 kilomètres from Vladivostock, and the earthwork was completed towards the close of 1904. The last 61 kilomètres was to be narrow gauge (2′ 6″).

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The exact arrangements made for local control of traffic (by what we should call Railway Staff Officers, etc.) are not very clear; but it is evident that the need for a separate staff to control the railway traffic,— as distinct from the staffs which arrange operations, distribute supplies and munitions, and so on,—has been recognised, just as it was on the German side in the war of 1870–71, and in the South African war.

The arrangements for guarding the line appear to be quite independent of the control of working and to be organised under the District Commands.

THE TRANSFER ACROSS LAKE BAIKAL.

The distance across the lake is 28 miles. While the lake was frozen over last year the troops crossed by marching and by sledge conveyance, the sledges which had been used in previous winters being supplemented by 3,000 more. The carriage and foot road was kept in order by gangs of workmen, being swept clear and provided with small bridges over cracks in the ice. It was marked out by posts and lanterns, which latter were lighted by night, and the Half-Way station was further lighted by petroleum flares. Shelters were built at four-mile intervals, and it may well be imagined how necessary they were when it is stated that the temperature would fall to 22 degrees Fahr. below zero. When snow fell or fogs came on bells were tolled at all shelters, between which also telephones were provided to give warning of cracks, etc.

Three or four troop trainloads a day were sent across, the troops having previously been given a day's rest at the Barracks near Irkutsk. The trains were sent down to a temporary lakeside platform, so as to arrive within the four hours after midnight, in order that the march across the lake might be completed in one day. All arrangements for despatch came under the orders of the Post Commandant. Baggage (and sometimes troops) was sent over by sledge; the batteries crossed with their own horses. One sledge would accommodate four men. The train loads were despatched at one-hour intervals, the intervening time being required for loading baggage, etc.

At intermediate halts food would be prepared by the regimental field kitchens (travelling); but the principal meal was taken at the half-way house, which had large waiting rooms for the different classes, and was properly warmed and fitted with cooking arrangements.

The march across was usually completed by 9 p.m.

ROLLING STOCK.

The gauge of the line, as in European Russia, is 5′. The engines are mostly American or Russian built. The clearance is large, allowing

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a continuous platform all round the engine; and the cab is closed in behind, so as to give some protection against the severe weather.

The standard engine is of the 4—6—0 type, both for passenger and goods traffic, and the principal particulars are as follows:—

Cylinders, 24″ × 26″.
Driving wheels, 72″ diameter.
Fixed wheel base, 14′.
Total weight, 62 tons.
Adhesion weight, 92,000 lb.
Diameter of boiler, 60″.
Firebox, 80½″ long, 36″ wide.
Heating surface—
Firebox, 119 sq. ft.
Tubes, 1,650 sq. ft.
Total, 1,769 sq. ft.
Tender capacity, water, about 4,000 gals.

The tractive force is not stated.

At least two powerful engines of the Mallet type have been supplied to the Siberian Railways recently. These are doubtless for working some of the more severe grades.

Some engines of the American type are also in use on the Siberian section (4—4—0, leading bogie). These are apparently the same as in use on the Russian State Railways, and of these the principal features are:—

Wheel base, 9′ 10″.
Compounded on the Worsdell system, outside cylinders 18½″ and 26½″ diameter respectively, stroke 26″.
Joy valve gear.
Weight of engine, 51 tons.
Adhesion weight, 26·2 tons.
Tender about 30 tons.

In passenger service this engine is calculated to haul trains of 200 tons at an average speed of 55 kilomètres (about 33 miles) per hour.

Some of the six-coupled engines, of similar type to the above mentioned, are constructed to burn petroleum, but this arrangement is probably not in use in Siberia. The passenger coaches are mostly six-wheelers, except the corridor coaches which are on bogies. The covered goods wagons, which are four-wheeled, will carry 40 men or eight horses, and are mostly equipped with some means of heating.

The normal load capacity per wagon is reckoned as eight tons.

According to information dated about June, 1905, the Russian Railways, including the Siberian line, need an additional 32,000 trucks. The various locomotive works in Russia are stated to be capable of turning out 1,100 new engines per year with a prospective further increase to 1,600.

TRAFFIC CAPACITY.

On the Siberian line (west of Lake Baikal) the train load varies from 20 to 39 trucks, but on certain sections the maximum is 24 trucks, thus of course involving a break of trains. At first the average

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distance between stations was about 20 miles, but additional stations have been opened and the average distance reduced to 15 miles or less; and it is stated that 13 trains a day can now be worked.

On the portion between Lake Baikal and the Chinese frontier the difficulties in obtaining fuel and water are great, and the normal capacity before the war was only six trains, four military, one passenger, and one supply train. The maximum load appears to be about 40 trucks. By adding additional stations and passing lines and improving water supply 9 trains a day could be worked, and this increase has apparently been effected. Of this number during last summer two were required for railway material.

The Manchurian Railway was well constructed, and trains of 44 trucks could be worked. Its capacity at the commencement of the war was at least as great as that of the Trans-Baikal line, but rolling stock and engines were deficient. Since then a large amount of rolling stock and particularly of engines has gradually been transferred from European Russia, of course at the expense of civil traffic in that part of the Empire until additional stock could be built. The average speed throughout seems to be something like 10 miles an hour.

TRAFFIC CARRIED.

In peace time the railway was carrying a considerable amount of traffic. For the year 1900, 758,000 tons of traffic were conveyed; but as the average haul is not stated this information is not of much value, though we may assume the mean distance to be considerable.

Under peace conditions the time-table of the Siberian line provided for four passenger and six goods trains in each direction; that is, the time-table contained these timings, but, as commonly the case on single lines, only so many of these trains were run as the traffic warranted. At the beginning of 1904 four military trains each way were to be provided as far as Krasnojarsk and three thence to Irkutsk. Actually from January 10th to February 1st (old style) five military trains each way were worked, and on February 1st (14th) the change to the military time-table was carried out. This provides two passenger trains and eight military trains for troops, stores and railway material. The change was effected without a hitch, 46 troop trains being actually *en route* to the East at this date. Civil traffic was suspended, but was in fact resumed again at the end of April, as was indeed practically essential, for the country districts alongside the line are now very largely dependent on it for supplies.

It would be of great interest to know the system adopted for the control of civil supplies, but particulars are lacking. As, however, traffic is only accepted without guarantee as to time of delivery, it may be assumed that simply surplus truckage is assigned to the merchants.

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The reports we have seen of the large numbers of trucks standing under load, both in European Russia and Siberia, seem to indicate imperfect arrangements for the release of rolling stock. There must further be great difficulties in rapidly clearing rolling stock and arranging its distribution, for at the outset collecting stations were very imperfectly equipped with sorting and marshalling sidings.

The average time between Moscow and railhead for troop trains may be taken as 30* days, including halts on the road; and an average inclusive running speed of 17 miles per hour on the Siberian section, and 10 miles per hour beyond Lake Baikal.

It appears that even during the War the Russians attempted to keep up a fast train service over the Siberian Line as well as that of military trains. This of course rendered the attainment of the maximum output more difficult. According to newspaper reports, however, 17 trains a day (12 military, 3 passenger and 2 railway stores) were being worked in the early part of this year. Deducting halts, the journey was being accomplished by troops in 21 days, or an average of 400 kilomètres per diem.

According to the Minister of War, between 8th February, 1904, and 25th March, 1905, the railway conveyed to Harbin 774,554 officers and men, 146,408 horses, 1,521 guns, and 351,000 tons of stores. Really, however, it appears probable that these figures include transport in both directions, and that it would be nearer a correct estimate to take 510,000 men, 93,000 horses and 100 guns as delivered at the front between February and December, 1904. In April, 1905, there were actually in Manchuria 411 battalions, 181 squadrons, and 168 batteries.

* But apparently at the outset of the war the troops reckoned about fifty days as the time of the journey from home to the front.

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THE BATTLE OF TELISSU OR VAFANGU.

FROM THE 13TH JUNE, 1904, TO THE 15TH JUNE, 1904.

By BT.-COLONEL J. D. FULLERTON, R.E.

I. DESCRIPTION OF THE BATTLEFIELD.
II. THE OPPOSING FORCES AND THEIR DISPOSITIONS.
III. NARRATIVE OF EVENTS.
IV. COMMENTS.

I. DESCRIPTION OF THE BATTLEFIELD.

Extent.—The battlefield area is bounded on the north by a line running east and west through Vafangu Station on the Manchuria railway; on the east by high hills east of Va-fan-vopen; on the south by the hilly ground about Chu-chia-tun and Tapinkou; and on the west by a low range of hills running from Tapinkou to west of Lunkoo.

Hills.—The general character of the area is hilly, the principal heights being those to the east of Lunkoo (right of the Russian position), and immediately to the south of the line Va-fan-vopen—Yud-sia-tun (the left of the Russian position). These hills commanded the country to the south fairly well, but the generally undulating character of the ground was on the whole rather favourable to the Japanese, as it allowed them to conceal the movements of their troops.

Rivers.—The Fuchau river runs through the area in a direction generally speaking north-east to south-west; it was not of sufficient importance to act as a serious obstacle, and was crossed by the Japanese without difficulty.

Railway.—The Manchuria Railway runs north and south through the area, and was in good order; it was freely used by the Russians to bring up troops during the action on the 15th June, 1904.

Villages.—There are no villages of any importance in the area.

Woods.—The country to the west of the line Lunkoo—Tapinkou is woody, and difficult to observe from the heights forming the right of the Russian position.

Roads.—The main road runs from Pulantien to Telissu, parallel to the railway. There is another main road from Pulantien to Fuchau, followed for part of its length by the Japanese Left Column. But

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most of the roads in the area are mere tracks and unsuitable for heavy wheeled traffic.

Weather.—The weather during the operations was fine, but there was a very thick fog early on the morning of the 15th June, which delayed the opening of artillery fire for about an hour and at about 4 p.m. it began to rain heavily.

II. THE OPPOSING FORCES AND THEIR DISPOSITIONS.

A. THE RUSSIAN FORCES.

On the morning of the 15th June, 1904, the Russian Force was distributed as follows:—

In command—Lt.-Gen. Baron Stackelberg, Commanding the I. East Siberian Rifle Division.

Covering Right Flank.	Ussuri Cavalry Brigade (Maj.-Gen. Samsonov).	1st Dragoon Maritime Regt. 4th Siberian Cossacks. 8th Siberian Cossacks. 1st and 2nd batteries, Transbaikal Cossacks.
RIGHT. North of *Ta-fang-chen.*	VIII. E. Siberian Rifle Division. IX. E. Siberian Rifle Division.	31st Regt. (3 battalions). 1, 2, 3, 4 batteries of Artillery.
CENTRE. North of *Yud-sia-tun.*	I. E. Siberian Rifle Division.	4th Regt. (3 battalions). 1, 2, 3, 4 batteries of Artillery.
LEFT. South of *Va-fan-vopen.*	I. E. Siberian Rifle Division.	1st Regt. (3 battalions) 2nd Regt. (3 battalions) 3rd Regt. 3 (battalions)
RESERVE. *Sisan.*	IX. E. Siberian Rifle Division.	33rd Regt. (3 battalions) 34th Regt. (3 battalions) 35th Regt. (3 battalions) 36th Regt. (3 battalions)
	35th Brigade, 31st Infantry Division, XVII. A.C.	139th Regt. (4 battalions) 140th Regt. (4 battalions) 1, 2, 3 batteries of Artillery.
	VIII. E. Siberian Rifle Division.	32nd Regt. (3 battalions)
Arrived during progress of the action on 15th June, 1904.	III. E. Siberian (Res.) Rifle Division.	9th Regt. (3 battalions).

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The total strength was 41 battalions of infantry, 3 regiments (15 squadrons) of cavalry, 2 horse artillery batteries (12 guns), 11 field batteries (88 guns); *i.e.*, about 36,000 men and 100 guns.

The Russian plan of operations was:—

1st. To hold defensively the line Lunkoo—Va-fan-vopen.

2nd. To make a flank attack on the Japanese right *viâ* the hills east of Va-fan-vopen, force them back on the line of railway, and thus cut their communications with Pulantien.

B. THE JAPANESE FORCES.

On the morning of the 15th June, 1904, the Japanese Forces were distributed in four columns, the exact composition of which has not been published. The cavalry on the extreme right were about 12 miles south-east of Va-fan-vopen; the Right Column was south of Chu-chia-tun; the Centre about Tapinkou; and the Left was advancing on Lunkoo from a point about 6 miles west of that village.

The composition of the force was as follows:—

In command—Lt.-Gen. Oku, Commanding II. Imperial Japanese Army.

III. Division. Lt.-Gen. Oshima.
- No. 5 Brigade
  - 6th Regt.
  - 33rd Regt.
- No. 17 Brigade
  - 18th Regt.
  - 34th Regt.

IV. Division. Lt.-Gen. Ogawa.
- No. 7 Brigade
  - 8th Regt.
  - 37th Regt.
- No. 19 Brigade
  - 9th Regt.
  - 38th Regt.

V. Division. Lt.-Gen. Uyeda.
- No. 9 Brigade
  - 11th Regt.
  - 41st Regt.
- No. 21 Brigade
  - 21st Regt.
  - 42nd Regt.

Also a Cavalry Brigade (no details known).

The total strength is very difficult to ascertain, as Reserve Brigades are said to have joined their Divisions; if this were the case the infantry would have amounted to 54 battalions, which, with the cavalry brigade and other troops, would bring the total up to about 70,000 men and at least 144 field guns.

The Japanese plan of operations was:—

1st. To hold the right, opposite Va-fan-vopen, with the Right Column.

2nd. To make a vigorous attack on the Russian centre, with the Centre Column.

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3rd. To make a flank attack with the Left Column against the line Ta-fang-cheng—Lunkoo and the country north of Lunkoo.

4th. To demonstrate against the Russian left flank with the cavalry brigade.

III. NARRATIVE OF EVENTS.

June 13th.—The Japanese Force was assembled at Pulantien (Port Adams), while the Russians were at Telissu and to the south near Va-fang-tien. The Japanese Commander decided to attack, and issued the following orders :—

1st. The cavalry to advance by the Pitsewo—Hsiung-yo-cheng road and threaten the Russian left flank.

2nd. The Right Column to move east of the railway on Chu-chia-tun.

3rd. The Centre Column to advance along the railway direct on Telissu.

4th. The Left Column to move along the Fuchau road, and roads east of it, on Wu-chia-tun and the right flank of the Russian position.

After a 12-mile march, opposed by small Russian detachments, the Japanese halted on the line Weng-chia-tun—La-Tzu-Shan—Yan-chia-kou.

During the day considerable reinforcements, brought up by rail, reached the Russians.

June 14th.—The Japanese continued their advance, and there was some sharp fighting between the Centre Columns and the Russian advanced troops about Va-fang-tien. The Japanese scouts discovered the Russian position to be along the line Lunkoo—Ta-fang-cheng—Va-fan-vopen.

At 3 p.m. the Japanese Right Column was at Chu-chia-tun, while the Left Column was in the neighbourhood of Tapinkon. The artillery bombarded the Russian position for about two hours without much effect ; and by sunset the Japanese were disposed thus :—

Cavalry : Shao-pao-tzu.

Right Column : Su-chia-tun—Pang-chia-tun (1½ miles west of Pang-chia-tun).

Centre Column : Pang-chia-tun—Weng-chia-tun.

Left Column (acting independently) : Towards Fuchau and Na-chia-ling.

The Japanese orders for the attack were :—

Cavalry to outflank the Russian left.

Right Column to hold fast on the line Su-chia-tun—Pang-chia-tun, and not to make any strong offensive movement until the attack of the Left Column from Fuchan had developed.

Centre Column to move to hills west of Ta-fang-cheng and attack the Russian centre.

Left Column to carry out an extended flank attack on Russian right from Na-chia-ling and neighbourhood.

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Further orders directed the Centre Column to make its advance during the night; the rest of the troops to act at 4.30 a.m. on 15th June.

June 15th.—1 *a.m.*—The Russian Commander decided to attack, and issued orders for the carrying out of the plan above mentioned. The flank attack was to be made by the 35th Brigade, 31st Infantry Division, XVII. A.C.; the column was intended to march at daybreak, but owing to a misunderstanding the troops did not leave their camp till 8 a.m.

2 *a.m.*—Desultory firing occurred along the Russian right front.

5.30 *a.m.*—The artillery duel between the guns of the Russian left and the Japanese guns south of Ta-fang-cheng and Va-fan-vopen commenced, after having been delayed by fog for about an hour.

The Japanese Centre Column advanced with difficulty and occupied the hills south of the line Lunkoo—Ta-fang-cheng.

6 *a.m.*—The Russian cavalry discovered the advance of the Japanese Centre Column.

6.30 *a.m.*—The Japanese Centre Column continued to advance, but its progress was slow.

8 *a.m.*—The Russian Flanking Column (35th Brigade, 31st Infantry Division, XVII. A.C.) started from camp.

9 *a.m.*—The Russian Commander discovered the Flanking Column had not advanced as directed and sent orders to its Commander to push on. There was some misunderstanding about these instructions, and a considerable delay in the advance took place.

9.30 *a.m.*—The Japanese Centre Column, assisted by a part of the Left Column which had come up from Fuchan, now began to press back the right of the Russian line, viz., the Lunkoo—Ta-fang-cheng position.

The Japanese artillery inflicted considerable damage to the Russian guns, no less than five batteries being practically speaking destroyed.

10 *a.m.*—The Russian cavalry to the north of Lunkoo had to retire.

10.30 *a.m.*—The Russian detachment from the Reserve at Sisan (consisting of the 34th and 35th Regiments and one battery, of the IXth E.S. Rifle Division) was ordered to the assistance of the troops on the Lunkoo—Ta-fang-cheng position and soon became heavily engaged with the Japanese Left and Centre Columns.

11 *a.m.*—The Russian 35th Brigade XVII. A.C. now came into action against the Japanese right flank, and heavy fighting took place, the Japanese being twice reinforced from the General Reserve.

A Russian regiment arrived by train and was sent to occupy the hills west of Vafangu Station.

11.30 *a.m.*—The Japanese attacks began to tell, and the Russian right from Ta-fang-chen to Lunkoo was gradually forced back.

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12 *noon.*—The Japanese cavalry, which had been delayed by the difficult country, came up and threatened the Russian left. Several rigorous counter-attacks were made by the Russians, but they were unsuccessful and a retreat was ordered.

1 *p.m.*—The Japanese ambushed a Russian column retiring west of the line Ta-fang-cheng—Lunkoo, and inflicted considerable loss.

3 *p.m.*—The Russians were now in full retreat. The 35th Brigade XVII. A.C., which withdrew rather late, suffered very severely, as did also the IX. E.S. Rifle Division in carrying out the retirement along the hills to the north-east of the Lunkoo—Ta-fang-chen position.

4 *p.m.*—The Japanese occupied the Russian main positions and the action ended. Heavy rain began to fall, and no attempt to follow up the Russians was made.

The Russian losses were :—

	Officers.	Men.
Killed	42	848
Wounded	81	2,442
	123	3,290

and 16 Q.F. guns.

The Japanese losses were :—

	Officers.	Men.
Killed	9	210
Wounded	58	903
	67	1,113

IV. COMMENTS.

1. *The Russian Plan of Operations.*

The objects General Kuropatkin had in view, when he detached Lieut.-General Baron Stackelberg's force to the south, were :—

1st. To relieve Port Arthur.

2nd. To defeat the II. Japanese Army before it could make a junction with the I. Japanese Army at Feng-whang-chang.

The scheme failed because the II. Japanese Army with its 70,000 men was quite strong enough to deal with Lieut.-General Baron Stackelberg's force without any outside assistance. As a matter of fact, the Russians, far from making an offensive advance to relieve Port Arthur, were compelled, on reaching Vafangu, to take up a defensive *rôle*, in order to save themselves from being completely cut off from Liao-yang. General Kuropatkin does not seem to have been aware of the real strength of the II. Japanese Army, and apparently imagined that the force sent to cover the Port Arthur

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Siege Force was merely a covering detachment unlikely to make a serious advance.

As regards Lieut.-General Baron Stackelberg's plan of action, it was clear, on the morning of the 13th June, that, owing to the great numerical superiority of the Japanese, a defensive *rôle* was the most suitable one; for if he had continued his advance southwards he would, in all probability, have been cut off from the Liao-yang Forces.

The Telissu position was a fairly good one; but, as is so often the case in undulating country, the hilly ground to the south and west of the position concealed the attackers' movements, while the woods to the west of the line Lunkoo—Ta-fang-cheng rendered observation difficult. The idea of an offensive movement east of Va-fan-vopen was a good one, but the misunderstanding regarding the action of the flanking force effectually prevented its attack from being brought to a successful conclusion.

2. *The Japanese Plan of Operations.*

The object of the Japanese was to cut off the Russian force, and the two flanking attacks, by the Left and Cavalry Columns, were arranged for this purpose. For some reason not at present quite understood (but said to be due to the difficult country) the cavalry failed to reach the ground east of Telissu in time, and the Russians were therefore able to retire with (comparatively speaking) little loss.

The general arrangements for the attack were most skilfully made; and the movements of the Left Column, which arrived on the scene at the exact moment when it was required, were extremely well carried out.

3. *Artillery.*

The Russians attribute their defeat, very largely, to the skilful handling of the Japanese artillery. The plan adopted by the Japanese gunners was to concentrate all their fire on one battery at a time, and in this way five Russian batteries were almost entirely destroyed in little more than an hour.

The Russian guns seem to have been much exposed, and this no doubt materially assisted their opponents.

NOTE.—The plan is reproduced from the *Voennyi Sbornik* by the kind permission of the Imperial Russian Authorities. As most of the places have different names in Russian, Chinese and Japanese, the names which appear to be most commonly used in the different accounts of the battle have been inserted in the plan.

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THE DESIGN OF TALL CHIMNEYS.

By Bt.-Colonel G. K. Scott-Moncrieff, c.i.e., R.E.

In the June number of the *R.E. Journal* Major Ainslie has called in question the method of investigation of the stability of tall chimneys as given in Part I. of *The Principles of Structural Design*, pp. 319–20. In this paper, as I understand, he has not objected to the actual steps taken in the investigation; but he has pointed out that, if the limitations of such investigation are applied in the case of many existing chimneys, these would be found to be theoretically unsafe.

I may perhaps state that my practical knowledge of the subject is very small; I never designed a tall chimney in my life and never built one worthy of the name; so my opinion is of little value.

The example which is given in the book, and which Major Ainslie thinks is unnecessarily heavy, was one that was built at Woolwich about 10 years ago, designed under the orders of the Superintendent of Building Works at the Arsenal (Colonel M. T. Sale, c.m.g., late R.E.). I saw the work in progress on the occasion of one of many visits to the Arsenal with a class of officers under instruction; and, if I remember rightly, some of the latter asked me how the stability would be investigated. So I got the plan of the chimney from the office of the Superintendent of Works and worked it out. As will be seen from p. 319 of my book, the problem was, not the design of a chimney with certain data, but the investigation, in an actual case, of the maximum wind pressure necessary to reduce the tension and compression to zero at the windward edge, as well as the maxima pressures on the brickwork and the foundations.

In selecting this example I did so because it was one designed and built under the superintendence of R.E. officers, on the principle that such designs, whether of bridges, roofs, chimneys or any other structures, were more likely to appeal to R.E. officers under instruction than those prepared in civil life. But in so doing I do not wish to imply that they are the best that can be designed, or that they are free from faults. Certainly some of the bridges shown in the Second Part of the book quoted cannot claim to be above criticism.

However, in this particular instance, I do not think the chimney is an extravagant one, if it is held that every such chimney should be calculated so as to allow for 50—60 lbs. of wind pressure and that no reliance should be placed on the tenacity of the mortar. These two

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points are questioned by Major Ainslie, and I think very reasonably questioned. I trust, however, that he will allow me to point out that neither of these points are part of my method of investigation. I shall deal with them both presently, but meantime let me turn to the only other point in which that method is questioned, viz.:—the position of the neutral axis. Major Ainslie says that this surely cannot lie up the centre of the shaft. Now, admitting that the investigations for the neutral axes of beams have been made mainly on those of fibrous material, such as wood or steel, and that the molecular conditions of such are probably very different from structures of stone or brick, I cannot see how, with our present state of knowledge, we can say that the position of the neutral axis in a beam of the latter will materially differ from one of the former material. That stone, brickwork and concrete have definitely measurable moduli of elasticity we know. We also know that in a tube of metal the neutral axis is at the centre, or "up the middle of the shaft." I can see no reason for supposing that, within elastic limits, the neutral layer of a symmetrically-built chimney will be other than a vertical plane in the centre of the shaft. If this be so the formulæ, on which my calculations for maxima and minima pressures are based, are applicable. This is the only point on which I can claim to have any method of investigation.

I think it is quite possible that many tall chimneys are built of a very much lighter section than would be involved in the rules quoted by Major Ainslie. In the footnote of p. 320 of my book I quote one which was destroyed at St. Louis in May, 1896, where the thickness was only 13 inches at 110 feet from the top. I can only suppose that the designer of this chimney either relied on his mortar to stand a definite amount of tensile stress or never expected a high wind pressure.

As regards the former point there can be no doubt that in nearly every brick arch there is a certain amount of reliance placed on the tenacity of the mortar. (I can speak with some confidence on this point, as I made a series of careful experiments on arches a few years ago in India. Besides, there is the distinguished authority of Sir Benjamin Baker, to the effect that at least 90 per cent. of the arches in the kingdom are in the condition of being partly in tension). If then mortar is trusted in the construction of arches, there seems to be no reason why it should not be trusted in chimneys. How far it is safe to trust the mortar must be a matter for local consideration; but I think the crucial point is not so much the tensile strength of the mortar, but its adhesive strength, a table of which is given on p. 39 of Part I., *Structural Design*. It is a subject on which one can obtain little general information. In every large masonry work which I have built of recent years I have always made adhesion experiments with the mortar I have intended to use.

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Again I quite admit that to take 50–60 lbs. as the wind pressure is usually extravagant, and that the overturning moment is much less than that arrived at in the investigation given in the example quoted from my book. I have indeed stated that "so great a wind pressure would seldom, if ever, be experienced in any part of the British Isles, and certainly not in the low-lying district of Woolwich." How much mean wind pressure would have been safe in that instance is a difficult question to answer. Possibly the records at Greenwich Observatory would be a safe guide. At my present station (the Curragh) I have calculated the stability of high enclosure walls on an assumed wind pressure of 20 lbs., but even that reduced amount gives heavier results than are usually adopted in practice.

It is all very well to say that theory is of no use and that what has been done safely before can be done again, but every now and then a big storm comes and causes disaster. I remember a case a few years ago, on the N.W. Frontier of India, when a wall was added to an existing wall on a frontier post. It was built according to custom as regards thickness, etc. One night, in a violent storm, it was blown over and killed several men. I should not like to have been the engineer who built it.

As regards the formula of Messrs. Babcox and Wilcox, I think it is one to be used with caution, because it evidently takes moments about the leeward edge, and I do not think this is sound. My reason for thinking so is that unless the brickwork is of exceptional hardness it will crack. Major Ainslie calculates a chimney where 7·14 tons per square foot is the compressive stress. From Table VIII., p. 33, of my book it will be seen that brickwork of London Stocks laid in lime mortar begins to fail at 5 tons per square foot.

The data in connection with the chimneys mentioned in Sir G. Molesworth's *Pocket Book* are insufficient for any general deduction to be made. They seem to me, however, to be lighter than those which would be designed under the London County Council rules.

After all common sense must guide one as to when such rules can be safely relaxed. If I were building a chimney on the top of an isolated mountain like Shekh Budin, I should design it very much more stable than one in a low-lying valley surrounded by other buildings.

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TRANSCRIPTS.

PROTECTION FROM LIGHTNING.*

FORTUNATELY, in this country thunderstorms of excessive violence are rare, or the inadequacy of the usual arrangement of lightning-rods would have long since been brought home to the public. In America, where severe storms are much more frequent, the inefficiency of the ordinary lightning-conductor has in this way been well established for some time, and, as a consequence, it has of recent years been quite common there to omit all provision of this kind even in the largest public and private buildings. In the latter case the risk is covered by insurance, but this is, of course, not entirely satisfactory, as none but material injuries can thus be made good. The need for further light on the efficient protection of buildings from lightning was evident over twenty years ago, when in 1882, a series of regulations for the instalment of conductors was published. Since then many buildings have been protected on the lines then laid down; but it was not long before it was recognised that the matter would have to be re-opened.

In their annual report for 1900 His Majesty's inspectors of explosives expressed this view strongly, in consequence of disasters due to lightning strokes at the Nobel factories at Krummel and Harum, Germany. In this position of affairs the Royal Institute of British Architects and the Surveyors' Institution, acting on the initiative of Mr. Killingworth Hedges, appointed a "Lightning Research Committee," being assisted to meet the expenses by grants from the Royal Society and the Royal Meteorological Society. Amongst the members of this Committee were Sir Oliver Lodge and Mr. G. Gavey, of the Post Office, whilst Mr. Killingworth Hedges acted as honorary secretary. The first step taken was to collect and collate accurate details concerning buildings struck by lightning. In the first instance information was sought both as to unprotected and protected buildings, but the mass of data became so voluminous that in the end only those cases in which the buildings were fitted with lightning-rods were investigated. One conclusion arrived at was that in Great Britain, during the years 1901 to 1904, over 500 buildings were struck by lightning, and of these the committee have details as to 115, of which 75 were unprotected, the remainder being fitted with rods supposed to be adequate by those responsible.

In a preface to the report, Sir Oliver Lodge points out that in protecting a building from lightning, two cases have to be provided for, which

* Extracts from an article in *Engineering*, 26th May, 1905.

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he calls repectively the "A" flash and the "B" flash. In the former the cloud discharges direct to earth, and ordinary lightning-rods may be considered as providing good protection against this form of discharge. In fact, they may by means of a "brush" discharge from the points prevent an actual flash passing, the electric energy involved passing quietly and harmlessly to earth, just as an overfilled reservoir may be quietly discharged through the ordinary water conduit or over the spill-way.

In the case of the "B" flash, points are, however, quite inoperative. Here the primary flash takes place between one cloud and another over the conductor. Owing to electric inertia the second cloud is instantaneously overcharged, and there is not time to quietly pass off this overcharge by the brush discharge, and as a consequence a flash passes from this cloud to the building below. Against this kind of flash the only safe protection would consist in enclosing the building in a complete metal cage—a process too expensive to be practicable in ordinary cases, and objected to also on the score of appearances. The condition of affairs in a "B" discharge may be likened to a valley having in it several reservoirs, one above the other. If one of the upper dams give way, those lower down are certain to be washed out, however adequate the spill-way provided may be to take care of an ordinary flood discharge. Further, the flood from the broken reservoir will not follow any defined channel. Obstructions and training walls, which will safely control an ordinary flood, will fail to restrain such an avalanche of water as follows the bursting of a dam. Similarly, in the case of the "B" flash, the discharge will not be confined to the lightning-conductor, but may take quite unexpected paths.

In the case of a "B" flash the heated air from a chimney forms a path which is often preferred by the lightning. A case of this kind is quoted in an appendix to the report of the Committee—viz., that of the Alexandra Hotel, Darwen, a building protected at the time of the accident by conductors on three chimneys out of seven. The lightning came down one of the chimneys 41 ft. away from the nearest conductor. The chimney was broken, the grate displaced in the room below, and the marble mantlepiece broken down. At the same time a horse was killed in a field outside.

This additional fact illustrates another peculiarity of the "B" flash—viz., the tendency to side flashes and oscillations. These are also well illustrated by the damage done in another storm to St. Pancras Church, Euston Road. Here lightning apparently struck the rod and set up violent electrical oscillations on a lead roof with which it was in contact at one end, but this roof was not otherwise earthed. The consequence was that the electricity made its escape through the gas and steam heating pipes. The former were fused and the gas ignited.

Generally speaking the damage done in protected buildings has not been excessive, so that the rods have provided partial protection at any rate, and have, therefore, a considerable value even in the case of "B" flashes. To increase this the Committee recommend some important modifications in the specifications drawn up by the Lightning-Rod Conference in 1882, and also propose certain simplifications by omitting provisions which are now found to be of no advantage. Thus it is no

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longer considered necessary to gild or platinise the points of conductors; iron rods are, moreover, preferred to copper as offering a greater resistance and thus reducing the surging of the current. Copper has, however, the advantage of being less easily oxidised, but where used on this account it is quite unnecessary for it to be of high conductivity. The necessity of avoiding bends and sharp angles in the conductor is emphasised. Conductors are best made as vertical rods fixed so far out from the wall of the building that it is not necessary to bend them round projections.

As matters stand, architects have commonly preferred copper to iron, as, a smaller section being used, the conductor was less conspicuous, and if in the form of a stranded cable could be bent round any projections or led into any corner and kept well out of sight. This practice is most reprehensible, since in an impulsive discharge of this character the current has a strong objection to being diverted from a straight-line path. Where iron has been used in the shape of a ½-in. rod, better results have been obtained, since it is easier to keep such a conductor straight and direct than it is to bend it.

In the case of factory chimneys it is advised that arched metal rods connected to the conductors should span the opening. Two main rods are advised, fixed on opposite sides of the chimney. Electric testing of the conductors when fixed is considered unnecessary, though the quality of the "earth" should continue to be tested. For this earth the use of coke or cinders is now considered questionable, charcoal or pulverised carbon being considered better. As a practical guide to architects and others responsible for the protection of buildings from lightning the Committee make the following suggestions:—

1. Two main lightning-rods, one on each side, should be provided, extending from the top of each tower, spire, or high chimney-stack by the most direct course to earth.

2. Horizontal conductors should connect all the vertical rods:—(*a*) along the ridge, or any other suitable position on the roof, (*b*) at or near the ground line.

3. The upper horizontal conductor should be fitted with aigrettes or points at intervals of 20 ft. or 30 ft.

4. Short vertical rods should be erected along minor pinnacles and connected with the upper horizontal conductor.

5. All roof metals, such as finials, ridging, rain-water and ventilating pipes, metal cowls, lead flashing, gutters, etc., should be connected to the horizontal conductors.

6. All large masses of metal in the building should be connected to earth, either directly or by means of the lower horizontal conductor.

7. Where roofs are partially or wholly metal-lined, they should be connected to earth by means of vertical rods at several points.

8. Gas-pipes should be kept as far away as possible from the positions occupied by lightning conductors; and as an additional protection, the service mains to the gas-meter should be metallically connected with house services leading from the meter.

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EMPLOYMENT OF TROOPS IN THE ATTACK AND DEFENCE OF FORTRESSES.*

Extracts from a Study by EMIL RITTER v. DEBNO-GOLOGORSKI, *Royal and Imperial Major of Engineer Staff, in the* MITTEILUNGEN ÜBER GEGENSTÄNDE DES ARTILLERIE UND GENIEWESENS, 1904, *p.* 981, *of a similarly named book by the Russian Lieutenant-General* KASBECK.

A book with the above title, published in 1902, was the 2nd edition of similar "Instructions" written in 1900 by G. N. Kasbeck, then Major-General and Fortress Commander in Iwangorod and now Fortress Commander in Warsaw. The "Instructions" were brought into force by General Kasbeck at Iwangorod and later at Warsaw, pending the publication of the 2nd and 3rd parts of the *Regulations for Duties in the Field.* They expressed the Russian views of measures to be taken in Fortress Warfare. The 2nd Edition has received more or less official sanction by being published in Russian Headquarter Circular No. 4 dated 5th January of this year (1904).

This study therefore concerns the 2nd edition, and more immediately the first part of it dealing with "Attack"; but is limited to a few questions of Fortress warfare in which the most important alterations appear in the 2nd edition.

It may be stated that the 800 numbers of the 1st edition were sold in a very short time; this fact elicits an answer in an affirmative sense to the recently much-debated question as to whether the framing of regulations for the attack and defence of fortresses was necessary or not.† This is further proved by the fact that Germany in her *Belagerungs-und Verteidigungs anleitung*‡ and France in her *Instruction Générale sur la guerre de siége* possess similar regulations.

The new edition of the Russian "Instructions" also gave its writer the opportunity to lay more stress than formerly on the influence of the heavy artillery of an army in the field in the progress of an attack on a fortress. For instance Kasbeck opines that the introduction of heavy artillery with an army in the field will revive the assault, and that this heavy artillery will play the same relative decisive *rôle* in the assault as the siege artillery in prolonged siege operations. This latter opinion is also held by Lieut.-Colonel von Gerwien. But in v. Lobell's *Jahresberichten*, 1901,

* Communicated by the Chief of the General Staff.

† With reference to the discussion of the Austro-Hungarian *Field Pocket Book for Officers of the Engineer Staff and Pioneer Troops* it is stated in v. Lobell's *Jahresberichten*, 1902, "Not only Sappers and Gunners but officers of all arms and of every rank must educate themselves for siege warfare as well as field warfare; this must not however be left to private study; the official instructions must be brought to general notice the same as the regulations for training in field warfare and orders for duties in the field."

‡ See *Kriegstechnische Zeitschrift*, 1904, p. 98, 3rd pamphlet.

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Lieut.-Colonel Frobenius states in opposition that, thanks to the growing interest taken by the army in siege warfare, the views are rapidly disappearing that siege warfare is the domain of siege and fortress artillery and that the corresponding battle between the two artillery forces, to which the other arms only play a subsidiary *rôle*, is the decisive factor. Lieut.-Colonel Frobenius further states: "There are some indications that the old idea, that questions of fortress warfare should necessarily be considered from a purely technical standpoint, is obsolete; one is beginning to realise that infantry and cavalry have a more important task to fulfil than merely to act as auxiliaries to gunners and sappers, and armies are ridding themselves of the bond caused by the temporary overestimation of the capabilities of the artillery arm." This view adopted by Frobenius can however only be treated as a side issue; it follows, as a natural corollary consequent to the disappearance of the last traces of Vauban's stereotyped attack, that fortress warfare partakes more and more of the nature of operations in which infantry plays the decisive *rôle* throughout; but the continuous and vigorous co-operation of the artillery is still indispensable.

The first six paragraphs of the Russian "Instructions" define the possible operations against a fortress (observation, blockade, investment). The attacker is warned against binding himself down to a definite method of attack during the whole period of operations; all measures he takes must be suited to the conditions of the defence. If the conditions of the defender have altered, a corresponding more expeditious method of attack must at once be adopted; the attacker must abandon his previous plan of operations, even if already in execution, directed against a fortress originally well-organised with a suitably strong garrison. Scarcity of over-head cover in the works of the defence (insufficient bombproofs and armoured cupolas) and want of flank defence of the intervals by the defending force, with a strong mobile force of field and heavy artillery of the field army on his side, are signs which justify an attacker in adopting more expeditious methods.

Regarding the further grouping of the subject and the representation of the various phases of fortress warfare, the "Instructions" follow the usual method of introducing the most important operations of the attacking force during a siege, pointing out their object step by step and giving short rules to be followed.

The attack is represented as a battle round a number of tactically important positions which the defence has strengthened by fortifications and has occupied at the right time. In these positions the so-called "advanced positions" (to be discussed later) are the first in which the defence offers a stubborn resistance. In order to give way step by step the defence will occupy various "intermediate positions" between the "advanced positions" and the main defensive belt (called the "main position") until eventually driven into the belt. If the attacker also gains the ascendency here, the defender continues his resistance in a "retrenched line" and finally in the enceinte. According to the "Instructions" the loss of the latter even constitutes no grounds for surrendering the fortress, the defence of which is still to be continued in

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a *reduit*, in order to facilitate the re-taking of the fortress by a relieving force which may appear at the last moment.

From the above one sees that Kasbeck bases his attack on a definite configuration of the fortress and well-defined conditions of defence. Allowing that the defence of a fortress, dependent as it is on various circumstances and combinations of circumstances, will take a different course in each particular case, and that therefore a previously assumed course can hardly be accepted,—yet one must recognize that the course assumed in the "Instructions" is the only possible one for the elucidation of a theoretical development of the various questions. From the regulation that the measures to be adopted by the attack must be adapted to those of the defence it will be seen that Kasbeck in no way lays down a hard and fast scheme for the belligerents.

The paragraph "General course of the siege" receives quite a new interpretation in the 2nd edition. The methodical, *i.e.*, formal (step by step) attack is subdivided as follows:—

1. The first course consists of the surrounding (isolation), the object of which is the complete isolation of the fortress from the outside in order to prevent relief and replacement of men and *matériel*. To gain this object a line of defence is arranged about 2½ miles from the works of the fortress; this line forms, so to speak, a screen behind which the necessary preparations are carried out, *i.e.*, movement of troops, construction of roads from the detraining station, establishment of parks; it is also the means of getting into touch with the enemy, with the object of determining the extent of front for attack. This phase of the siege is called the *preparatory period* and the position taken up the *preparatory position*.

2. Under cover of this position the attacker pushes up his forces against the front to be attacked, working concealed; with the assistance of covering troops he constructs, at a distance of 1¼ to 1¾ miles from the belt line, a number of siege batteries and pivots; brings up his siege guns and arms all his siege batteries simultaneously in a pre-arranged night. This second line forms the *main attack position* and is destined for the artillery duel with the fortress. More detailed instructions for the conduct of the above operations are given in the 3rd section of the "Instructions."

With this preface the "Instructions" then deal with a few questions of siege warfare.

Organisation of the Siege Troops and of all Other Means of Attack.

The organisation of the besieging army follows the same rules as the division of an army in the field (Corps, Divisions, Brigades, etc.). This organisation is however not to be regarded as hard and fast; it may be necessary for officers in charge of besieging operations to alter it during the various periods of the siege. For instance, certain details of the parks and transport may be detached from one unit and allotted to another; or certain companies of Sappers, for whom there is no other occupation, might be organised in battalions and employed in the Engineer Park, etc.

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As compared with other powers Russia possesses a special advantage as regards siege troops in that she can reinforce them by means of fortress troops;* in peace time these fortress troops are trained in fortress duties and should be especially useful in the siege of a fortress. On the other hand Russia suffers from the disadvantage that she still has a scarcity of mobile siege artillery in the same sense as that existing in Austria-Hungary, Germany and France; this artillery enables an attacker to attack advanced fortified positions or even badly equipped parts of the belt without his siege park.

In Russia, as is the case also in Germany and France, the siege artillery park comprises, besides the various components employed by us, the field railway necessary for transport, together with telegraph and telephone *matériel* and *personnel*, as well as all materials for the construction of the batteries. The park is not regarded as a depôt, but as a separate command which is responsible, from the time the park is taken over at the detraining station, for placing the guns in the batteries ready for action. In accordance with this principle the laying of the field railway and the regulation of the traffic over it, the forwarding of guns and ammunition, the construction of batteries and the work of arming the batteries, form part of its task. The artillery park is divided into sections (Issuing and Intermediate Depôts) the composition of which depends on their special task and the methods of fire adopted by the batteries allotted to them. To each section are allotted several batteries further subdivided into groups for the construction and arming of the siege batteries. The subsidiary parks (Issuing and Intermediate Depôts) are connected with the batteries and main park by a field railway, and the main park is connected with the advanced base by means of ordinary railway. The Commander of the Park has charge of the supplies and traffic on these connections.

From the above it will be seen that the whole of the artillery is united in the Siege Artillery Park and is placed under the orders of the Commander of the Siege Artillery. It would be better to place the siege artillery *with all its parks* under the orders of the officer commanding the section of investment. This would naturally necessitate a corresponding organisation of the fortress artillery. The decentralisation of command thus sought would prevent that delay or undue haste in carrying out work which usually accompanies every centralised system.

The commanders of the various battery groups in the fighting line are

* According to Drygalski's *Organisation of the Russian Army in 1902*, and therefore before the war in the Far East, Russia possessed in Europe 50, and in Asia 9, Battalions of Fortress Infantry; these were partly organised in regiments and partly distributed in single battalions amongst the various fortresses. Their training is similar to that of the other infantry; but a special point is made of their prospective employment in fortified places, including the serving of guns and execution of earthworks. As regards Fortress Artillery Russia is supposed to have had 58 battalions of 230 companies. 5 independent companies and 1 separate command. This artillery counts in peace time as part of the stationary garrison of the fortress and remains in the fortress when war breaks out. In technical troops there existed :—12 Fortress Companies and 4 independent sections or detachments, 13 Mining Companies for the defence of fortified harbours and mouths of rivers, 2 River-Mining Companies for the Vistula and Narew, 8 Fortress Balloon detachments and 12 (?) Fortress Telegraph detachments, which are subdivided according to their strength into 3 classes; besides these there were 1 instructional park for ballooning and 1 electro technical instructional company.

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therefore in Russia under dual control: (*a*) In an artillery technical sense, they are under the control of the commandants of subsidiary depôts, who are in turn under the orders of the commandant of the main park; (*b*) In a military sense they are under the control of the commander of the section of the investment, or under the orders of a senior artillery officer allotted to the front of attack. (But the siege artillery commander is responsible for fire discipline). Besides the group commanders there also exists in the "section" a special "artillery commander of the section," who, however, only commands the field artillery and mobile heavy artillery* in that section.

This organisation of the Siege Artillery Park† certainly makes the fortress artillery self-supporting and independent of other technical troops; but has the disadvantage that it increases the size of the already very comprehensive and bulky park, and renders more difficult the training of the already very much taxed artillery troops. It is true that this training is to a certain extent lightened in Russia by allotting certain duties—for instance the illumination of the field of fire, which in our service is performed by fortress artillery—to certain special troops. In conclusion one may remark that such a comprehensive organisation of the siege artillery park (incorporating the field railway) is not applicable to every theatre of operations; for instance in mountainous country the use of the field railway is almost entirely excluded in stretches where it is most wanted, *i.e.*, between the parks and the batteries. But still it may be affirmed that, in localities where it is of use, such an organisation is of material assistance in simplifying the service and in avoiding disputes concerning responsibility.‡

Contrary to the siege artillery park the engineer siege park is only a depôt. It is called Engineer Depôt and has arrangements similar to those in our service. In a siege it is subdivided similarly to the siege artillery park. It therefore consists of a main depôt and advanced intermediate and entrenching depôts. The forwarding of *matériel* from the main depôt onwards is done by means of wheeled transport. The transport of siege *matériel* up to the detraining station is carried out by placing railways, rivers, etc., at the disposal of the siege troops, these

* As already mentioned Russia possesses no mobile siege artillery organised as such; therefore, only such mobile artillery detachments can here be referred to as are organised, in the event of war, by detaching a number of mobile heavy guns from the siege artillery regiments. To these would also be added the 7 Mortar Regiments with, altogether, 24 batteries of six 6" (15·24 c.m.) field mortars. But as these latter are, on account of their small range, ill adapted for use as mobile siege guns, they are (in accordance with the latest reports) to be replaced by the 15-c.m. howitzers now on trial.

† Contrary to the practice in other states Russia possesses in peace time a properly organised siege artillery. The necessary guns and *matériel* are in peace time allotted to the 4 siege artillery regiments. As there are supposed to be 4 parks (each of about 200 guns) in Russia, 200 guns would be allotted to each siege artillery regiment or 6 guns to each of the 32 companies. The advantages of this organisation are not quite apparent; for in peace time the regiment is hampered with all sorts of details of administration and interior economy, and the training suffers; whereas in war time the regiment has to precede the artillery *matériel* and gets separated from its park on account of the necessary preliminary preparations and (in Russia) pending the construction of the field railway.

‡ Such differences—principally between gunners and sappers—occurred even in Vauban's times and repeated themselves at Antwerp, 1792, Badajos, 1811, and to a small extent at Paris, 1870–71.

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lines being in charge of the line of communication staff. The transport from the detraining station onwards is in the hands of the artillery, which also, as above mentioned, supervises the construction of the field railway. This latter is destined exclusively for artillery transport; it may however, if available, be used by special order of the siege commander for transport of wounded, sick and supplies. This limitation of the use of the field railway might follow as a matter of course in the investment of a middle-sized fortress, on account of the comprehensive nature of the artillery transport requirements and the usual scarcity of railway *matériel* and rolling stock; yet such regulations do not seem out of place, as they prevent the field railway being overloaded, ensure the fullest possible use of regimental and other transport with the besieging force, and preclude from the very outset any latent hopes of the assistance of the field railway. Since every delay is a gain to the defender, and delays are unavoidable in using rivers as lines of transport for the siege parks, on account of the slower journey and the frequent shifts entailed, it is better to use railway lines for the transport of siege *matériel* and river lines for the regular forwarding of supplies and for transport of sick, etc.

ORGANISATION OF COMMANDS IN THE ZONE OF INVESTMENT.

The division of the line of investment (preparatory position) into sections and sub-sections, the allotting of the section troops and reserves, and the settlement of the size and composition of the general reserve, follow by direction of the Officer Commanding in accordance with generally recognised principles. Section Commanders are made fully responsible for the security and protection of their sections. All troops are under their respective Section Commanders, but only in urgent cases have the latter unlimited control of the siege artillery. In the front of the attack the Officer Commanding personally directs operations. But the regulation is not meant to limit the freedom of decision and independence of the Section Commanders; they are therefore justified (in accordance with the "Instructions") in ordering an advance in the attacking front, if they consider a favourable opportunity presents itself. This is in accordance with the spirit of modern regulations, which encourage individual action in every battle. The idea applies also to an attack on a fortress. In the case under discussion a Section Commander, whose troops have been in continual touch with those of the defence, might possess later and more detailed knowledge of the immediate state of the defender than the Officer Commanding in rear, in spite of the latter's numerous connections by telegraph and telephone; it is therefore only natural to demand that the former should without hesitation make the fullest possible use of any opportunity for a forward movement. As the sections of the front of attack are generally allotted to Divisions, the Section Commanders possess the means of initiating an opportune attack and of effectively occupying the position gained. On account of the high rank of such section commanders, and the grave responsibilities they incur by acting in accordance with their own independent decisions, the danger that this independence of action will betray them into hasty

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action at an inopportune moment is slight and is not borne out by military history. The condition of Paris on the arrival of the first German troops offers an example to the contrary; on this occasion Moltke said that a surprise might have succeeded, if a subordinate leader had undertaken it on his own responsibility. In this respect our own *Infantry Training* states: "Each Commander must seek to gain the initiative in the preparation and execution of a combat. Bold resolution, based on an intelligent appreciation of the situation, is indispensable in a leader. In doubtful cases the bolder plan is always the better. A mistake in the choice of a plan does less damage than hesitation and inaction. Where possible surprising an enemy must always be aimed at."

The Russian "Instructions" further lay down that during the advance in one section the commanders of adjoining sections must co-operate. This also is in accordance with our *Infantry Training*, which states: "Commanders in the firing line, who are best able to notice the effect of our own fire and must rapidly avail themselves of any advantages the immediate situation offers, may also give the impulse for the execution of the assault. They act however on their own responsibility. The remaining commanders at once co-operate." In the sections of the front of attack Generals of the higher ranks take command and relieve each other day by day; they are designated "Generals of the Day." The working out of details,—viz., the division of working parties, their supervision, the arrangements of the infantry positions and the approaches, the erection of sign posts, the construction of dressing stations, the guarding of the approaches, etc.,—is the duty of the "Trench Major" of the section (usually a staff officer of engineers), who has several engineer officers under him. It will be seen therefore that the technical officer has to deal simultaneously with technical and military matters, and it is therefore necessary that he should be master of both.

Preliminary Investment.

Decisions necessary for the conduct of the siege are given in the 3rd Section of the "Instructions." These agree generally with the views accepted by most of the Great Powers, but are naturally suited to the special cases of Russian fortresses, organisation of the troops and their methods.

The preparatory operations are concerned with the preliminary investment of the fortress, which also in Russia is caried out principally with cavalry and the advanced troops of the investing army. During this period the preliminary reconnaissance is carried out by the General Staff, and by the officers commanding the artillery and technical troops. The Officer Commanding the investing army points out to the arriving troops their preliminary destinations. The line connecting these various destinations corresponds to our preliminary line of investment, and, according to the "Instructions," should be 4,400 yards from the defensive belt. There is no particular name for this position, as is the case with the subsequent ones; for it only serves the purpose of enabling the

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troops arriving to equalise the differences in the lengths of their marches, to take up their new organisations, and to bring up the heavy artillery of the field army.

CLOSE INVESTMENT.

From this preliminary line the investing army advances simultaneously, if possible, against the whole circumference of the defensive belt of the fortress up to a distance of about 4,650 yards from the works of the defence. This line is called the line of close investment or the "Preparatory Position." In the zone of close investment advanced positions of the enemy may be met with, round which a number of obstinate engagements may develop. These positions may be strengthened by fortifications, for the overwhelming of which field artillery may not suffice. For this reason the attacker must at once bring up the heavy guns of the field army. For the establishment of the line of close investment the attacker need not wait for the siege park. The line should be strengthened by field works, and serves as a base for the formal attack; in this line the siege park is awaited.

Whilst the wording of the 1st edition of the "Instructions" defines the line of close investment as "withdrawn from the effects of the guns of the fortress," the 2nd edition admits the possibility of not only advancing this line to within 2½ miles of the fortress but also of maintaining that position without the presence of the siege park. This decision is in accordance with the views of those writers who, relying on the experience of the 1870–71 campaign, advocate the capture of any advanced positions and their inclusion in the line of investment; and in opposition to those who advocate their capture being deferred until rendered necessary after the preparations for the artillery attack have been completed. The proper course can only be decided by the particular circumstances of the case, and depends on various considerations, such as strength and attitude of the enemy, the nature of the advanced position, its command over the defensive belt and over the field of attack, the general condition and preparedness of the fortress, the nature of the country, etc. Even after the investment has been made as close and complete as possible, the rapid capture of advanced positions is still to be sought as soon as one can count on their being occupied for a prolonged period without the assistance of the siege artillery. This decision in the 2nd edition also possesses the advantage of not forcing an attacker to inaction, and of enabling him to use the heavy artillery of the field army in overcoming the resistance of the advanced positions, for which purpose it might in most cases amply suffice. The contention that such a procedure discloses prematurely the direction (not frontage) of the attack hardly holds ground, for a defender has many other means of ascertaining this, if he carries out his reconnaissance and intelligence duties properly. He can moreover already infer this from the general conduct of operations, the state of the railways leading to the fortress, the choice of the detraining stations and the activity of the thousands of men employed there for weeks, the construction of the field railway and arrangement of the siege parks. To wait until the arrival of the siege park would force the

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attacker to make, in the greatest haste and with extraordinary exertion, the comprehensive preparations which precede the opening of fire, and would give the defender unnecessary opportunities of rectifying mistakes and of strengthening himself.

Organisation of the Close Position of Investment.—In order to anticipate all doubt and friction, which is more liable to occur in fortress warfare than in field operations, the extent and duties of the most important commands are exactly defined. Without unduly restricting the independence of the commanders of sections, the Officer Commanding the investment is given the necessary independence in order to personally supervise the conduct of the attack. In accordance with the regulations for field operations the protection of the sections is secured by outposts, which are however made stronger in fortress warfare on account of the repeated attacks they have to withstand. The garrisons of the pivots in the sections avail themselves of natural cover in their vicinity, and only occupy the positions allotted to them to repel attack.

This latter instruction, which has for its principal object the comfort of the troops, would however only be possible in a country well intersected by roads, where the garrison could be accommodated in the vicinity of the pivots by means of natural cover. In a flat country, affording no cover, the troops would, in order to avoid the enemy's artillery, be accommodated some distance to the rear, and might easily arrive too late to occupy their position. There might be neither time nor labour for the provision of artificial cover (shelter and overhead cover) or for the construction of inter-communication trenches, since at this period the commander of the section might only have available for the strengthening of his section of the investment line the technical troops allotted according to the organisation of the troops under his command. (In our army at most a company of engineers and 3 to 4 detachments of regimental pioneers). When one further takes into consideration the requirements of the section besides fortification—*e.g.*, camps and shelters, improvement of communications, clearance of field of fire, etc.—there appears in most cases no other course possible than to accommodate the troops near the positions they have to occupy, provide alarm posts there, and allot to them a portion of the outpost line which they can relieve daily. Thus it would be possible to reduce technical labour to a minimum, spare the troops, and keep them capable of resistance. This method should be all the more feasible, since the fortifications should not form a continuous line, but the fullest possible use should be made of the configuration of the ground by grouping them in localities where attack may be expected. The arming of the close position of investment is carried out by the heavy artillery of the field army and by a portion of the field artillery (machine guns might also well be used). The remainder of the field artillery remains in reserve. In the more important positions, according to the Russian "Instructions," batteries (normal siege batteries) should be constructed for the expected siege artillery. In case of necessity these are armed with guns, which could be used for bombarding the forts or such targets as do not sufficiently come under the fire of the heavy artillery of the field army in the preparatory position.

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THE CHOICE OF THE FRONT OF ATTACK.

The choice of the front of attack is incontestably one of the most important considerations of the Officer Commanding the investment. It is of course understood that he can only make his choice after careful personal reconnaissance and prolonged deliberation; yet he will be able to clear up the situation as regards its most important aspects—as far as existing fortresses are concerned—by means of the plans prepared in peace time. The "Instructions" make no mention of such plans although there can be no doubt that they exist in Russia as well as in other countries.

In the choice of the front of attack the Russian "Instructions" lay special stress on the direction of the railway line nearest the fortress. Up to a certain point one can agree with this view; it is remarked in parenthesis that the most advantageous case is that in which the railway line debouches immediately in rear of the chosen front of attack; this is however very seldom the case. In view however of the complete development of the technical means of the present day (amongst which the field railway and the automobile take the first place) too much account should not be taken of the above-mentioned advantage, particularly if its acceptance involves other serious disadvantages. The choice of a front of attack on either side of a line of communication forfeits all chances of surprise; an attacker should not give these up if he wishes to avail himself to the fullest possible extent of the advantages of the initiative, in spite of the present very complete means of observation and intelligence possessed by the defence. Moreover the disadvantage of transporting to a flank, entailed by the choice of a front of attack which is not too far on one side or other of the line of communication, is not prohibitive as soon as the flank shifts can be carried out under cover, particularly if the field railway and other means of transport at the disposal of the attacker are taken into consideration. The distance of the detraining station should not be less than 6 miles from the defensive belt, and at the time the *matériel* for the field railway arrives the attacking troops are already in the investing position, which is at a distance of 4,400 yards or less from the defensive belt. Since observations by balloons, which are most to be feared, could hardly be carried out nearer than in the belt, it will be seen that, apart from the difficulties of observations at so great a distance, quite small elevations of ground or low cover will suffice to screen the loads on the field railway, barely 5 ft. high, from the observer's plane of sight ($\frac{1}{20}$). Even supposing the defender has discovered the field railway, he still does not know, except in very special cases, which forts or intervals it is intended to attack.

There is a further reason which might induce an attacker to digress from a line of communication. Localities where railway lines enter the line of forts are usually strongly fortified and well defended by artillery; therefore an attacker might be influenced to choose another direction of attack, since his supplies of *personnel* and *matériel* cannot be unlimited, although they are not restricted to the same limits as those of a defender.

Siege guns and their ammunition constitute some of the most difficult

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stores to replace or bring up. It is true that they are placed in readiness in peace time; but their number is limited by their prohibitive cost, and can hardly suffice for every possible attack on a fortress during a campaign. Therefore an attacker can only dispose of a certain limited number of guns, which might be less than that of the fortress.

This circumstance will force him to look for a front of attack where, in spite of his inferiority of strength, he may gain a relative superiority of fire. This is the main object of an attacker in fortress warfare, as well as in operations in the field; and the number of guns that a defender is able to mount in a fortress does not play such a decisive *rôle* in his power of resistance. For instance, should one portion of the defensive belt be cut off from another by a river, possess few lines of supply with communications, and have bridges within range of the guns of the investment,—and should this portion of the defensive belt be limited and commanded by the surrounding country,—it will offer such prospects to the attacker for the attainment of a relative superiority in the artillery battle that he will choose it as his front of attack, even if his base is indifferent and he is forced to make a considerable digression from his lines of communication. That such cases can occur is proved by glancing at those fortresses which are situated at the confluence of lines of communication by water or in marshy country.

Method of Attack.

With the choice of the front of attack the commander of the investing army also determines the *method of attack*, in which he has to choose between the normal (siege) attack and the more expeditious attack (assault). To this latter method which, according to latest ideas of fortress warfare, should be carried out by the heavy artillery of the field army, the writer of the Russian "Instructions" devotes a special paragraph which is given in detail.

"45. *Assault.*—This may be undertaken when—

(1). The works and intervals possess no bombproof cover.
(2). The surprised fortress possesses no armament for the intervals, or an insufficient garrison.
(3). The investing corps has at its disposal numerous field artillery and sufficient heavy guns of the field army.

The advocates of the assault recommend the following procedure:—The investing troops, divided into various independent columns, advance towards the fortress and appear simultaneously at different intervals in order to force the defender to scatter his forces; the attack is then prepared by the heavy artillery of the field army; after which the intervals are to be forced. From this it follows that an assault only offers prospects of success when the fortress is of obsolete construction, when it does not possess sufficient bombproof cover against 15-c.m. howitzers or 21-c.m. mortars and has no means of traversing guns under cover to protect the intervals, or when the fortress is surprised. When these

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conditions are absent it is better to adopt the normal method of (siege) attack than the assault, and to begin with a bombardment."

The *Joint Plan of Attack*, to be submitted by the officers commanding the siege artillery and the engineers to the Officer Commanding the investment should comprise:—The limitations of frontage of attack, its subdivision into sections and sub-sections, the fresh grouping of all troops, the connections of the parks to the front and rear, the establishment of the siege artillery and the construction of the main attack *position*. Since the latter is not mentioned in the 1st edition it merits closer inspection.

The instructions respecting it are as follows:—Under cover of the preparatory position (4,700 yards distant from the belt) the main attack position is prepared at a distance of 3,500 yards from the belt. In this the artillery of the attacker, destined to conduct the decisive battle with the artillery of the fortress, plays the decisive *rôle*. By reason of the proximity of the fortress and the corresponding danger to the works to be constructed in the main position, care must be taken to construct these step by step and in concealment, and to direct the defender's attention to other portions of the investing line. The works are constructed under the superintendence of engineer officers in accordance with a pre-arranged plan; the first thing done is to provide shelter trenches for the covering troops in advance. Day by day the cover provided is extended and the old cover made more perfect; after some days of this procedure a sort of backbone of the main position is developed, which must be perfected during the period preceding the arrival of the siege park, so that the mounting of the siege artillery may possibly follow in one night. The batteries are further perfected by the establishment of points of observation (observatories, balloons), construction of telephone lines, and other arrangements necessary for firing. From the above one sees that in the "Instructions" the term "main attack position" comprises the artillery position as well as the covering position.

In von Gerwien's instructional book on fortress warfare the average distance of the artillery position is given as $1\frac{3}{4}$ to $2\frac{1}{2}$ miles, and that of the covering position as $1\frac{1}{2}$ to 2 miles; according to the *Leitfaden für den Unterricht in der Befestigungs lehre auf den Königlichen Kriegsschulon* the former is $1\frac{3}{4}$ to 3 miles and nothing is given for the latter; the French instructions give no distances at all. Regarding the covering position the Russian "Instructions" lay down generally that it should be as near the belt as the hostile fire permits, and sufficiently far in front of the siege artillery to prevent damage from shells directed at the siege artillery. It will be seen, therefore, that the idea prevails of advancing the artillery as well as the covering position as near to the belt as possible, in order to use only one artillery position; moreover the Russian "Instructions" give the smallest figures for the respective distances. According to German views the exact following of these distances has no important bearing on the conduct of the attack, as soon as the siege guns are advanced to within effective range and there are good means of observing their fire.

The "Instructions" give no detailed rules as to frontage and nature of the covering position, the moment for advancing it, its construction and armament, connections to the rear, or division of the garrison. One can

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however recognise from the general rules and the accompanying plan that the arrangements do not differ from the usual form of a modern normal (siege) attack. The presumption that several days are necessary for arranging the main position (close line of investment) is specially significant as according with present views, *i.e.*, that the works of the covering position and the batteries are separated not only as regards space but also as regards time. The "Instructions" do not indicate how long the work is likely to last. Von Gerwien gives the whole period as five nights, and allots two nights to the covering position and two to the construction of batteries; so that the arming of the latter could be effected in the fifth night and fire could be opened on the sixth day after the commencement of the work mentioned above. In these calculations he assumes however that the laying of the field railway is commenced simultaneously with the covering position, that it is led to the sites for the batteries, and that materials for the construction of the batteries are ready to hand. The calculations of von Gerwien therefore represent the most favourable circumstances which, as we learn from the 1870–71 campaign, hardly ever exist; on the contrary the establishment of the 1st parallel, barely $1\frac{3}{4}$ miles long, before Strasburg could only be accomplished between the 29th and 31st August (two nights) by using 59 battalions, and in most cases from 2 to 4 nights were necessary for the construction of batteries. The laying of the field railway might also not be so quickly accomplished in fortress warfare as von Gerwien assumes, since the arrangements connected with it,—such as shunting stations, stations and park arrangements,—are much more numerous and more extensive than in ordinary field operations, and therefore demand more time; the contemplated immediate use of the line for railway traffic makes its construction much more difficult. One would not therefore go very far wrong if one allowed double the time given above for the works of the main attack position. But the stipulation contained in the Russian "Instructions" to arm all the batteries in one night is unlikely to be accomplished.

The moment for advancing the covering position is dependent on the commencement of the laying of the field railway necessary for the preliminary construction of the batteries. It can only be worked out further for each particular case by labour and time calculation, since it depends on conditions of country or cover, favourable or otherwise to the laying of the railway.

As regards the strength of the siege artillery, its employment and fire discipline, the "Instructions" take the same views as those advocated in most German publications and also in the French instructions. Superiority in number of guns and sufficient ammunition ready to hand are laid down as the only unconditional stipulations for the attainment of certain success and for opening fire. How large the superiority, expressed in numbers, should be is not given in official or semi-official regulations (German, French and Russian); but this is more closely indicated in *Grundriss des Festungs Krieges* by W. Stavenhagen and in our *Pocket Book for Officers of the Engineer Staff and for Pioneer Officers*. For the conduct of a decisive artillery attack in the front of attack the former demands $1\frac{1}{2}$ times, the latter double, the number of guns which, inclusive of guns in reserve, the

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defender can bring to bear in the immediate front and adjacent to it. It may be true that the latter figures, which have taken root as a convenient rule to be followed in artillery circles, mean a sure success; yet as mentioned elsewhere, this number of guns will not always be at the disposal of the attacker; nor will they always be absolutely necessary to attain superiority of fire, since the latter depends also on the superiority of the artillery positions, the guns themselves, fire discipline, direction of fire, observation, amount and supply of ammunition. It is not clear why the siege gunner should alone possess the right to enter battle unconditionally with two-fold superiority; certainly the aim of other arms is also always to gain superiority of force. Apart from this however, how often has it not happened that weaker forces have gained a victory over a stronger adversary? Does not an attacker possess a very important superiority, even with equality in number of guns, when one considers that his guns are nearly always better than those of the defence, that his positions only offer small targets, that the employment of enfilade and reverse fire is easier for him than for the defender who is bound to his defensive belt, etc.? One may therefore assume that an attacker, who understands how to make clever use of the prevailing circumstances in his favour, may accomplish his task with a less number of guns than is given above, and that the above rule as to numbers only becomes imperative when the positions of the attack offer no advantages; these numbers therefore only give a maximum. In order to prove this aspect of the question some examples from the 1870-71 campaign are given.

According to the supplementary report by Lieut.-General Muller of the bombardment of Paris, the German artillery of 76 guns not only maintained its position during the bombardment of Mont Avron on the 26th December against the enemy's superior artillery, but gained an important success by forcing the defender to abandon Mont Avron during the night of the 29th December. In January, 1871, the German artillery was in a similar position in attacking the southern front of Paris with extraordinary success, having 110 guns against the French 180 or 190.

There is a contradiction in the paragraphs of the Russian "Instructions" dealing with *Employment of the Siege Artillery* and *Opening of Fire;* the former places the destruction of the shelters and magazines in the defensive belt before the silencing of the defender's artillery; while the latter lays down that the siege battery should direct its fire against those batteries of the defence which have been located at the time of opening fire. The latter instruction would appear to be the more correct, since, in accordance with tactical principles, the nearest and therefore most dangerous targets (in this case the artillery positions ready for action) are the first to be attacked, and not the infantry garrisons remaining under cover or the munitions of war in the magazines.

The orders given in the Russian "Instructions" as to the use of the field artillery do not appear very advantageous. In accordance with these, the field artillery is to assist the siege artillery in front of it from the preparatory position (4,700 yards), for which "it is considered adapted on account of the effective shrapnel fire of modern quick-firing guns." Although no one denies the necessity of the co-operation of modern field

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artillery in future fortress warfare, opinions differ as to its employment. Many writers (Frobenius, Hubner and partly Rohne), who consider field artillery ineffective in the bombardment of the forts, would employ it in the destruction of the living forces of the defender and in fighting these when they are either behind cover of the fortifications or behind cover in advanced positions; others however (Stavenhagen, Kasbeck) include the field artillery in the battle against the guns of the fortress. The principle must be followed that at no period of the investment is an attacker justified in not using *all* his means to gain a quick and decisive effect, and that he is therefore bound to use them according to their capabilities to the fullest possible extent. The mobility, improved range and effect of the field artillery enable it by changing position to engage the guns of the fortress with success even within effective range of them. Thus it can be of material assistance to the siege artillery. This becomes all the more evident when one considers that the targets the first-named writers have in mind for the field artillery do not exist at the commencement of the artillery battle, and having no targets it would be forced to inaction. Therefore the second view is the right one, but with this provision (as far as the Russian "Instructions" are concerned), that the field artillery allotted to co-operate with the siege artillery should be in advance of the latter, *i.e.*, in or in rear of the covering position, since the grazing nature of its fire is more effective there and is not masked by the siege artillery. By leaving it in the more distant line of investment one could not make full use of its mobility, and one would have to abandon all idea of its co-operation from any concealed positions, which might even be within range of the guns of the fortress. The Russian "Instructions" give no further hints as to subsequent employment of the field artillery, although well merited by modern field guns. The light field howitzers, the value of which has nowhere been discussed in detail, should have received special attention.

The following train of thought is adopted in the discussion of the fire discipline of the siege batteries. Endeavours should be made first of all to silence a portion of the artillery of the defence whilst the remaining portion is only kept employed. This can be attained either by grouping a superior number of guns against the target or by a quicker rate of fire. These instructions should be compared with the procedure recommended by von Gerwien, as exponent of the German view, who states: "At the commencement of the artillery battle the hostile fire from the most dangerous batteries must first be silenced whilst the others are merely kept employed." The difference between the two views is principally that in the first the artillery of the defence is to be reduced in *sections* and in the second in *order of importance*. Which of these plans is the best, *i.e.*, which would be the quickest in overwhelming the artillery of the defence, could only be decided by concrete cases, in which the nature of the country would most influence the plan to be adopted. Theoretically one may only surmise that, in adopting the method of overwhelming a section of the artillery of the defence, an attacker might be enabled, after overwhelming a particular section, to take up more advanced artillery positions from which he could bring enfilade fire to bear on the remaining

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portion of the front of attack, and thus more quickly attain superiority of fire throughout its whole extent.

With respect to the commencement of fire the Russian instructions are similar to the French and German ones; and demand that the fire of the attacking artillery should only be opened when the whole of the siege batteries have been constructed, armed, supplied with ammunition, connected to the rear, and provided with observing stations and means of communication.

THE INFANTRY ATTACK.

As is the case with most technical literature dealing with instruction in fortress warfare, the *Infantry Attack* forms the least considered portion of the Russian "Instructions"; with barely a few lines they dismiss the functions of infantry within a zone of roughly a mile, although the latter will be the theatre of the most vehement and bitter engagements. Of a connection between the infantry and artillery attack there is also no mention; the form the infantry attack will take is merely given in general terms. In favour of this representation of the infantry attack it may be urged that it ascribes to the defender, even after the overwhelming of his artillery, such power of resistance that he can bring the infantry attack to nought; and therefore this attack is represented as a "series of day and night engagements extending throughout the whole extent of the front of attack." This standpoint is remarkable in that it contradicts those military writers who assume that, with the attainment of superiority of artillery fire, the whole of the resistance of the defence is broken. That this is not the case is shewn by the present campaign, as far as can be gathered from the reports in the papers; the resistance of the Russians, even in positions strengthened by fieldworks only, was only broken by a formally fought out infantry attack and bayonet charge, in spite of an artillery battle lasting for days and of the superiority of fire gained by the Japanese.

As is commonly the case the "Instructions" regard the covering position as a base for the infantry attack. They are not very plain however regarding its commencement; they merely state: "Under cover of the siege artillery, which gradually destroys all means of defence, the attacking infantry occupies the country in front, advancing by rushes, and is assisted by the field artillery." The "Instructions" therefore do not clear up the existing differences of opinion with respect to the moment for launching the infantry attack. The differences of opinion are especially with respect to the following questions:—Should the attack only be launched (as demanded by some writers) "when fire effect is beginning to impress the enemy after his own has been reduced"; or should the attack begin at the same time as the siege artillery opens fire, and continue during the artillery battle until a position is gained from which the next hostile position can be swept by rifle and machine gun fire? Since the moment for commencing the infantry attack principally depends on the resistance offered by the defender, and cannot therefore be judged in advance, General Kasbeck may have desired to leave it to the judgment of the Officer Commanding the

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besieging army, without binding him to any hard and fast rule. Reviewing the above aspects of the question theoretically, one may therefore say that in the former procedure (launching the infantry attack after gain of superiority of fire) the fire superiority gained by the artillery is regarded as the only decisive factor in the attack on the defensive belt, infantry only being added to gather the ripe fruit; in the latter procedure (commencing the infantry attack when the siege artillery opens fire) it is intended on the contrary to aim at mutual assistance by employing both arms (infantry and artillery) simultaneously, and thus to gain the desired object by more expeditious and approved methods. But in order to comply simultaneously with the double demand in the last-mentioned procedure, *i.e.*, reduction of the defender's artillery and assistance of the infantry attack, numerical superiority of guns and unfailing amount of ammunition on the side of the attacker are more important factors than they would be in the first-mentioned method.

In the first method the separation of the artillery and infantry attack is clearly defined; while in the second the moment when one merges into the other is as unnoticeable as possible, and the defender might—if such were within the bounds of possibility—be more easily misled. The further case might occur that an infantry attack becomes necessary for the very purpose of enabling the besieging artillery to open fire, on account of the defender's artillery being withheld; for the discovery of retired and well-masked batteries is rendered more difficult from a distance, but is quite impossible in their vicinity, if there are hostile lines of infantry pushed forward. An example of such failure is given by the first part of the South African War, in which the English could not succeed in discovering the Boer positions. Plevna and the Boer War (at Magersfontein, Colenso and the Upper Tugela) have effectively demonstrated how unsuccessful is a mass of fire against insufficiently reconnoitred positions. In the case of the defender withholding his artillery the attacker must endeavour to undertake a reconnaissance in force, under cover of his siege artillery placed in readiness for action.

The German training regulations for field artillery speak in a similar sense and state, in the description of the danger incurred by a noticeable separation between the artillery battle and the infantry attack, "It is however to be borne in mind that quantities of ammunition expended against fortifications, with no garrisons or only weak ones, are of no appreciable value. This is to be dreaded when the separation of the battle into a long drawn-out artillery preparation and subsequent infantry attack is also apparent to the defender. The effect of the artillery against the main points will be most remunerative if the infantry, by creeping forward and keeping touch, force the defender to occupy his lines and show his troops. It is one of the principal tasks of leading to combine the gradual deployment of the infantry with the protection afforded by the artillery fire." By proceeding thus the defender is forced—unless he wishes to dispense with the co-operation of his artillery—to open with his flat trajectory guns on the advancing infantry, and to push forward the guns into positions with little or no cover, where they are rained on by the shrapnel of the attacking artillery. The

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attacking infantry need not fear the high-angle armament of the defender (about ⅔rds of his whole armament), since indirect fire cannot as a rule follow moving targets quickly enough. If the advancing infantry of the attacker comes within rifle fire of the defender, it discontinues its movement and takes natural cover. On account of its mobility and shrapnel fire the field artillery accompanying the infantry (also the siege artillery) is able to take part with success in engaging the flat trajectory guns directed against the attacking infantry.

If the defender has pushed forward lines of infantry in advance of his belt (which, according to the Russian methods of defending a fortress, may with certainty be assumed), the covering position may already be within long distance rifle range of the hostile infantry; therefore as soon as the attacking infantry leaves the covering position it may be forced to open fire within effective rifle range from the nearest hostile position. In this case (bombardment of the infantry lines) the resulting assistance rendered to the attack by the attacker's artillery will not be particularly effective and continuous during the attack, on account of the frontal nature of its fire and the increasing danger to the infantry from the great dispersion of splinters and shrapnel with curved trajectories. Therefore, before launching the infantry attack, one must either wait until the defender's infantry has been shaken by the siege artillery or, as in field warfare, delegate the task to the field artillery which accompanies the attack; in the latter case the best gun to bring to bear on the infantry lines, as also on their means of cover, will be the light field howitzer (counted as part of field artillery), because it can rapidly change from common shell to shrapnel, and because it is suited to oppose counter-attacks and in case of necessity to quickly change position. According to Hoffbauer: "The expenditure of the same weight of ammunition from several light, as opposed to few heavy, field howitzer batteries corresponds better with the liberal provision of light cover in the positions of a mobile war strengthened with field fortifications. The advantage of hitting 2½ times as much cover with lighter shells and making certain of penetration is of more value than increasing the force of the penetration with a considerably increased expenditure of ammunition." The few isolated cases of improved cover, capable of withstanding the penetration of field howitzers, do not enter into the question, for which reason the German regulations also state: "The penetration of improved cover or casemates, although very desirable, is not to be considered absolutely necessary." From the above it follows that the time for the commencement of the infantry attack must be settled for each particular case, since it depends on the one side on the organisation of the defence in the immediate front of the fortress and on the resistance of the defender, and on the other side on the superiority of guns.

Regarding the *Method of Infantry Advance* from the covering position against the fortress, the "Instructions" merely mention, without giving distances, that the advance should be by rushes; but the distances can be readily inferred from preceding principles. The covering position, as previously ascertained, is from 2,000 paces to 2,666 paces distant from the belt, and the Russian method of defence presupposes intermediate

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positions; therefore an attacker of a Russian fortress will not find that undefended zone which would exist according to those writers who bind the defender to the defensive belt and deliver up to the attacker without offering resistance the country in front between the distances of 2,666 paces and 1,200 paces. Therefore also against Russian fortresses—as is confirmed by reports from Port Arthur—it is out of the question to cover the zone intervening between 2,200 yards and 1,000 yards in one swoop. With the procedure advocated by von Gerwien there will also be no unprotected zone of above depth; in accordance with this procedure, the outpost position to be occupied by the defender should be arranged in exactly the same way as the investing line of the attacker, and should be pushed forward for the better protection of the forts to a distance compatible with the strength of the garrison and effective protection of the guns of the fortress; this distance will generally not be more than 1 kilomètre (·621 mile), but beyond the position will be the outpost companies with the necessary picquets and sentry posts. For the above reasons the attacker, on leaving the covering position, must be prepared for "serious encounters" with the defender, and will even at this early time be forced to employ rifle fire and to advance in rushes. In consequence of the above-mentioned circumstances the number of rushes is not indicated in the "Instructions," and this is also in complete accord with modern views.

With reference to the *Division of the Infantry for the Nearer Attack*, the Russian "Instructions" incline towards the French ones; they similarly distinguish between two bodies of troops,—covering troops and advanced groups,—corresponding to the tasks to be undertaken by the infantry in the front of attack, *i.e.*, the protection of the section and the battle for the capture of fresh positions. The task of the covering troops is to occupy the position captured, to maintain it, and to protect the troops in rear; they are under cover and in trenches, and offer a passive resistance. The advanced groups consist of single detachments of troops, usually detachments or companies of sharpshooters, and take post in front of the occupied position. These groups have to advance, fighting step by step, towards the fortress, and observe the activity of the defender. For this reason they are in continuous touch with the enemy and utilise every opportunity of involving him in a skirmish, and thus capture a fresh position in which they at once entrench themselves. This cover serves in turn for the establishment of still further infantry positions. The conduct of these troops is therefore offensive.

Let us compare this division with the distribution of outposts advocated by German writers and ourselves, which seeks to attain the same object as the Franco-Russian one, yet differs materially. The mode of attack of our distribution consists in this: the new infantry positions, gained by having driven back the defender during the day, are entrenched for considerable distances at night by working parties under cover of covering troops, and are perfected and placed in communication with the positions in rear during the following days. From the above it is seen that, whilst the Franco-Russian method adapts the elastic form of an attack in the field to that of an attack on a fortress, the Austro-German

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procedure chooses the stiff and immovable method of outposts. It follows from the nature of the two problems—security and attack—that they cannot be solved by one and the same body of troops. For whilst the duty of protection only presupposes a passive engagement, best carried out by close groups or advanced posts, the contemplated infantry battle demands freedom of movement in all directions and cannot be bound to the maintenance of the security of a particular point or section. It therefore follows that the capture of fresh sections must devolve on special bodies—as intended in the French and Russian instructions. That the outposts should also be able to assist vigorously, if possible, is a matter of course, and is anticipated by the last-named instructions. The first method moreover gives to subordinate commanders the opportunity of immediate and independent action in making the fullest possible use of favourable conditions for attack. In the second method the complicated system of command from the rear has to be put in motion, the advance organised and various preparations made, which not only means that a correspondingly great loss of time (and of immediate advantages) is incurred, but that the defender's attention is drawn to the procedure in plenty of time and he is able to take counter measures; besides, the latter method uncovers larger masses of troops to the enemy and must lead to much greater loss. But, in spite of the disadvantages inherent in the last-mentioned (Austro-German) method, it must be acknowledged that there are not unimportant advantages; these consist of unity and increased effectiveness in action, and of a methodical and simultaneous advance throughout the whole extent of the front of attack, which cannot be the case with the isolated actions of the generally weak commands of the first (Franco-Russian) method. The Austro-German plan ensures therefore, when successful, a greater probability of a further rapid progress in the attack.

No general rule can be given as to which is the better method, since it depends in each case on the particular condition of the defender. If, however, one imagines to oneself the distribution of the foremost forces of the defender from the time the attacker leaves the covering position (2,666 paces distant) until he occupies the position of assault (266 to 400 paces distant), one may imagine that, as the attacker advances, the defender will draw his forces closer together and retire them nearer the belt; during the time that the attacker is occupying the covering position the defender will only have weak covering troops in advance; but he will have to oppose close lines to his enemy occupying the position of assault. The attacker therefore will be able to utilise both methods of pushing forward and gaining ground, viz., the Franco-Russian at the closer distances and the Austro-German at the far distances; in the former case the attacker will be enabled to sneak up to the close hostile lines with small detachments and patrols, and in the latter case he can advance in long and close lines up to the weak chain of outposts of the defender.

There is a further question to be considered in regard to the infantry attack, and that is the method to be adopted in driving the defender out of his infantry positions. Should rifle and artillery fire suffice, as generally assumed, or will it be necessary to drive him back at the point of the

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bayonet? Although a purely theoretical answer to this question is useless, one may state, in respect of the disclosures of the Russo-Japanese war, that an energetic and tough defender will even fight at the point of the bayonet before ceding his position. In the said war this happened in the battles in the field (nothing reliable is yet known about the battles round Port Arthur); therefore why should it not happen in fortress warfare, when the conditions of holding positions are much more in favour of the defender? The danger threatening a defender, that when he retires the attacker will penetrate at the same time to the next position or to within the belt, may be avoided in the same way as in operations in the field, *i.e.*, by an opportune occupation of the position in rear with reserves and by the advanced troops clearing the front.

The technical works in connection with the infantry attack are regulated in accordance with special instructions; these follow the generally recognised principles of a modern attack and need not be further explained. It need only be mentioned that the fullest possible use should be made of the ground; and where such is unsuitable, deep, inconspicuous and well-masked cover should be provided artificially.

The Assault.

In the measures to be taken for the *Assault* the Russian "Instructions" first fix the conditions under which the Officer Commanding the besieging army may decide on this closing act of the attack on the fortress; the greatest weight is laid on the destruction of the trenches and flanking defences of the intervals, and it is pointed out that it is better to defer the assault if these conditions have not been fulfilled. The breaching of the escarp demanded in the 1st edition of the "Instructions" is left out of the 2nd edition; from this one may conclude that in Russia also it is intended to use appliances for assault, and that they are preferred to the tedious and questionable bombardment with the object of breaching; in modern fortifications moreover there are no more walled escarps.

The *Mining Attack* is still, and rightly, mentioned, although it is allowed that its use will only be necessary in certain cases. But in spite of this, and contrary to views held elsewhere, Russia still considers mining operations of the highest importance, and such exercises are practised every year at the camps of the Engineer troops.

As of special importance in deciding to assault the "Instructions" mention the moral depression of the garrison of the fortress. Should this be present before the destruction of the material means of defence, and be ascertained to exist beyond doubt, the Officer Commanding the besieging army must at once decide to assault the front of attack.

The "Instructions" dealing with the preparation and conduct of the assault agree with our views on the subject. It is only noticed that they lay special stress on surprise, and therefore recommend that the enemy should be deceived; this should be enhanced by organising assaulting columns on neighbouring parts of the frontage. Would not the man deceive himself who at this moment still believes he can deceive the defender as to the choice of the front to be attacked?

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In conclusion the "Instructions" do not bring to notice forcibly enough the necessity for the most exacting mutual co-operation between all detachments and means of assistance used in the assault. This demand is made all the more important by the fact that all preparations for the assault can only be made in the last hours, *i.e.*, under strong pressure of time, since otherwise the danger threatening the defender will be made too easily apparent. Therefore, to reckon with some certainty on the success of the assault, all concerned must be minutely instructed as to the parts they have to play, and must have practised them beforehand, that is learnt them from the very beginning.

The second part of the Russian "Instructions" deals with the Defence. Its discussion is being reserved for a later study.

BOOKS CONSULTED.

v. Brunner: *Permanent Fortification*, Vienna, 1901.

v. Brunner: *Fortress Warfare*, Vienna, 1899.

v. Leithner: *Permanent Fortification and Fortress Warfare*, Vienna, 1893.

Smekal: *Attack in Fortress Warfare*, Vienna, 1902.

Smekal: *Directions for the Instruction in "The Art of Fortification in the Royal Academies,"* Berlin, 1902.

Smekal: *General Instructions of the 4th February*, 1899: *Siege Warfare.*

v. Lobell's Annuals on the *Alteration and Progress in Military Matters*, years 1901, 1902 and 1903.

Stavenhagen: *Elements of Fortress Warfare*, Sondushausen, 1901.

Stavenhagen: *Elements of Instruction in Fortification*, Berlin, 1896.

v. Gerwien: *Fortress Warfare.* An addendum to the books of instruction on the art of fortification and war, Berlin, 1902.

v. Hoffbauer: *The Employment of Field Howitzers in Field and Position Warfare*, Berlin, 1901.

v. Muller: *The Action of the German Fortress Artillery at the Sieges, Bombardments and Investments of the Franco-Prussian War*, 1870–71 (Supplementary pamphlet: "The Bombardment of Paris, 1870–71"), Berlin, 1904.

v. Drygalski: *The Organisation of the Russian Army*, Leipzig, 1902.

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REVIEWS.

DETAILED HISTORY OF THE RAILWAYS IN THE SOUTH AFRICAN WAR, 1899—1902.

(R.E. Institute, Chatham. £2 2s.).

The "Detailed History of the Railways in the South African War," lately published in two volumes by the Engineers' Institute at Chatham, contains much valuable information drawn from experience, many useful deductions, and some interesting historical reading. In the second volume there are sixty-one photographs and ninety-three plates, showing what damage was done by the enemy, how it was temporarily and how permanently repaired, plans of armoured trains, and much matter that is of purely technical value.

Of course we shall be told that it is a waste of space to discuss the matter. In case of an invasion of England the use of our railways (to condense the argument) may be left to the Fleet, and, happily, we shall never again be called upon to invade a foreign State. But it is not the best but the worst that one has to consider in making preparations for war, and a hostile force might quite possibly evade the Fleet. Again, in conjunction with some other Power, we might be compelled to invade, shall we say, Ruritania. The lessons of these volumes, therefore, demand consideration no less than the other lessons of the war.

Before considering some of the questions here raised we may be allowed to praise the admirable method in which the history is written. It is based on reports drawn up for the information of the War Office by the officers who were in charge of their departments. Not a word is wasted, but the logical conclusions are clearly indicated. And the result is more interesting than the merely literary historian would imagine.

Half-a-dozen useful articles might be drawn from this work, but for the present we shall be content to indicate its contents in two directions. The history of the war, from an engineering point of view, is graphically set forth, and the importance of a thoroughly equipped—that is, a carefully-trained—military railway staff is fully explained. Continental nations have long been alive to the importance of railway military organisation, and have laid down proper instructions. The matter has also been closely studied in India, "where on occasion 50,000 men and more have been moved to the frontier." But, as the writer of one chapter guilelessly remarks:—

"In England, on the other hand, the great railway companies have from time to time moved troops, and it has not been necessary to ask for

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military assistance; as a consequence neither the organisation nor the necessary rules had been thought out in 1899."

Yet the deduction from experience is as follows:—

"The facts which have here been set down make it abundantly clear that for the management of railways in war there must of necessity be a Military and not a Civil Controlling Staff; and, further, that it would be to the advantage of the Army generally that there should be an appreciable number of officers conversant with at least the elements of railway traffic work."

This is the proper system. Have we that appreciable number of officers? Of course, good work is being done at Chatham and elsewhere, but is a sufficient number of officers engaged in studying the rudiments of railway work, or shall we have to rely, as in the South African War, on a small railway staff, assisted by intelligent men whose experience is chiefly drawn from other branches of engineering? It is not enough to make honorary colonels of the managers of the great railways. We need the trained officer to act in conjunction with them, and there should be a large, not a small, railway staff, intimately associated with the Intelligence and Mobilisation Staff.

Some of the defects of our system in the early part of the war may be indicated. We find the traffic delayed on the whole system for three hours and more while an armoured train protected a convoy of cattle on the march; a station commandant who would not let an engine coal because the coal stack formed part of his defences; troops conveyed by rail without reference to the railway department; trucks left loaded for days on sidings; telegrams sent from different staffs at headquarters so confusing that the railway department did not know whether to send 40 or 120 trucks of provisions to railhead, and then was not sure whether it had sent the right sort; unnecessary movements over short distances by rail, as once when a brigade, having to move a distance of 80 miles by rail and 60 by road, was 48 hours late at its destination owing to the delay caused by entraining and detraining, and to the fact that the line had other services to perform as well as its transport. The most signal instance of this lack of co-ordination was seen when General French did not know whether or not to off-load a large number of trucks sent to him at Naauwpoort Junction, as he had not been instructed whether he was to hold or evacuate the place. "This absolute blocking of Naauwpoort Junction to such an extent as to prohibit any shunting naturally caused chaos in the traffic department." One of the first lessons the soldier on a railway in war time has to learn is that a loaded truck is no truck at all for transport purposes.

Afterward, we have the story of order evolved from chaos. As the Orange Free State gradually fell into our hands the necessity of centralising the control of the railway became more and more evident, and the Railway Staff Officers were removed from the control of the Station Commandants and placed under the orders of the Director of Railways. Results justified the wisdom of the decision. Soon the Imperial Military Railway organisation was created, and we have here the record of its work. This history contains Sir Percy Girouard's

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figures. From October, 1899, to June, 1901, roughly 140,000 truckloads of Army stores were forwarded from the Cape ports, namely, 300,000 men in 10,000 waggons, 193,000 animals in 22,000 waggons, 446 guns in 500 waggons, 4,175 road transport waggons in 5,000 trucks, and 570,000 tons of stores (of which one-fifth were forage) in 100,000 waggons. All this despite breakages on the line caused by the enemy and the necessity of supplying the civil population. While the Army was advancing from Bloemfontein to Pretoria the repairing corps had to mend no less than 61 bridge spans, of which 22 were over 100 feet in length, and of which many involved the construction of deviations and the building of temporary bridges. Some of these deviations were, in fact, solidly-laid railways over a mile long on either side the river. Fifty-seven culverts were mended, 28 sets of crossings put right, and 17 serious breaks set in order. Yet at the Vaal River the reconstruction department was only eight days behind the Army.

The management of the line after Pretoria had been taken is really a masterpiece of swift organisation. The details of the establishment are set forth here in full, and we may be allowed to doubt if anything so complete exists in England to-day. Several tables show what the Imperial Military Railway was able to do in the moving of troops. Take the movement of troops between April 5th and April 11th, 1901, to repel the invasion of Natal. The troops were concentrated between Volksrust and Dundee. Including those placed in support of the force or to replace necessary garrisons 882 officers, 23,536 other ranks, 32,836 animals and 45 guns were concentrated from Klerksdorp, Vereeniging, Bloemfontein, Springs, Kroonstad, Aliwal North, Springfontein, Harrismith, Middelburg—in fact, the garrisons of these towns were satisfactorily concentrated on a single line of rail. This could not have been done under the old system. Only Sir Percy Girouard's organisation made it possible.

Briefly, under his system the Director of Railways alone was responsible to the Chief of Staff for the working of the lines, and the military and civil staff of the Imperial Military Railway was responsible to him, the duties of each being clearly defined in several orders. The relations between the fighting arm and what may be called the traffic arm were established by the order that Commandants and Officers Commanding must communicate their requirements through their Railway Staff Officers to the Assistant Director of Railways. The duties of the Assistant Directors of Railways were described as follows: To be intermediaries between the Army and the technical administration of the railway; to see that the ordinary working of the railway was so carried on as to secure the greatest military efficiency; and, most difficult of all, to see that the demands of the Army interfered as little as possible with the working of the railway system as a whole.

One further lesson the book contains. The Imperial Military Railway knew well how to make use of trained civilians, as the history of the Railway Pioneer Regiment shows.

An article which has outlined a record of technical work and shows how by organisation order grew out of chaos may seem dull to the general reader; but who can read without a spring of generous emotion

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the story of the volunteer engine-driver who, "with his fireman dead beside him and himself shot through both arms, brought his train safely through a force of the enemy, one hand on the lever and one on the brake?"—(*Morning Post*).

In our issue of the 29th ult. we welcomed the above publication, although space being scanty we were obliged to dismiss it in brief. We now recur to the two volumes, the first of which is letterpress and the second full to repletion with illustrations, including sketch plans, many and diverse. We congratulate the agents, Messrs. W. and J. Mackay and Co., Limited, Chatham, upon so excellent and serviceable a couple of volumes. Some of the views showing the nature and extent of the damage done during the war are very realistic. As a practical epitome of the subject by the Director of Railways himself this series could hardly be excelled.

Perhaps the most difficult task which the Director had to face was the education of the army with regard to the services of the railway and the railway staff in war. The great point which had to be made intelligible, he tells us, was that the railways should be regarded as one totality, the chief object being to expedite the large movements of troops and supplies required by the Headquarters Staff. Of course, few people who do not know South Africa could realise the immense area covered by the theatre of war unless volumes like these brought the facts into prominence.

We understand that the War Office, in the first place, arranged to publish in four volumes the general report by the Director and the more detailed accounts of various services. It did publish the general report. The Treasury stopped the publication of the rest from motives of economy. The R.E. Institute then decided to publish the remaining volumes themselves.

Sir Percy Girouard's report traces from the very beginning the evolution of a department which had to be created, and which unavoidably made many mistakes before it had got into proper working order. Sir Percy did herculean service at a critical time in the history of his country, and his country will not forget it.—(*South Africa*).

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NOTICES OF MAGAZINES.

Electrical Review.

June 10th, 1905.

High-Speed Traction.—*The Marienfelde-Zossen Experiments.*—This number contains some account, by Mr. Mudge, late of the Allgemeine Electricitäts Gesellschaft, of the experiments carried out last year.

The line used is about fourteen miles long, very straight, having only two decided curves, and those of 1¼ miles radius. The line thus practically consists of almost four miles at each end for acceleration and seven miles for running in the middle. The rails are about 82½ lbs. per yard, and the track had been stiffened and well ballasted since the former experiments.

The car body was 69 ft. long and 9¼ ft. wide, with a machine room containing starting switches and rheostats in the centre, and compartments for registering instruments and passengers at the ends. The weight was about 100 tons loaded, plus certain balancing weights afterwards added.

Three-phase current was used, the highest recorded voltage in the car being 14,150. It was collected by six sliding bows placed in groups of three at each end of the car.

Perhaps the most interesting observations were in regard to air resistance. It was practically established that at 50 miles an hour a pressure of 7 pounds per sq. ft. is attained at the front end; at a double speed the pressure is quadrupled, and at treble speed the pressure is increased ninefold. By shaping the nose of the car, however, a ten per cent. reduction of these figures can be effected.

With respect to power, the 100-ton car, at 50 miles per hour on the level, requires about 150 horse-power to move; doubling the speed means increasing the power six times; and trebling the speed to 150 miles per hour necessitates an increase of power to eighteen times (2,700 h.p.).

The balance of the car is most important. Below 100 miles per hour no great oscillation was experienced, but above that speed a rolling or swinging lateral motion was apt to be set up to so great an extent as to endanger the overhead work. It was found that this could be remedied by arranging the heavy weights of the motors and transformers symmetrically. Actually counterbalancing weights were used on this car.

Bringing the car to a stand, again, was not easy. Very great brake pressures were necessary—at 110 miles per hour the initial pressure had to be 1½ times the weight of the car, and the car could not be stopped in less than half a mile, which means a retardation of 3¼ miles per hour per second. Particulars of the brake are not given, but it was apparently rather complicated.

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Signalling was also a difficulty. At 125 miles an hour persons standing on the platform could only be approximately identified when 50 feet or more off, and, unless the light was very good, signals could not be read unless of large dimensions or very pronounced colour. It is thought practicable, however, to make an arrangement for electric signals by means of a special brushing contact alongside the rail.

The general conclusions drawn as to the design of car, etc., are as follows:—

(1). The car body should be kept as near the rails as possible.

(2). Any apparatus placed above the floor should be as light as design will permit.

(3). The overhead contact should preferably be above the car.

(4). The motors should be mounted flexibly on the axes of the bogies.

(5). The front end should be wedge shaped.

(6). The car body should be supported on the bogie frames at a little distance from their centres, so as to allow a certain amount of flexibility in rounding curves.

(7). All heavy weights should be central or symmetrically placed.

(8). The wheel base of the bogies should be long, not less than one-fifth of the body length.

(9). The road should be as straight as possible, and if two lines are used they should be separated more than is customary in present practice.

(10). On curves the approach should be lengthened out considerably.

The main interest of the experiments of course centres round the results attained as regards train resistance. Experiments so far made, and formulæ propounded, seemed to shew that the attainment of such high speeds was practicable only at enormous expenditure of power, and one theorist went so far as to characterise such hopes as a mere "iridiscent dream." It is true that those who commented on Mr. Mudge's paper confined themselves to remarks on the future of electricity as a motive power for ordinary train services and the economy of central generation of power. *Apropos* of these experiments it was remarked, for instance, that a single phase electric locomotive had recently been tried in comparison with a freight engine in hauling a 50-car train, and had shewn great efficiency, particularly in starting. (Weight 135 tons, capacity 1,500 h.p., drawbar pull 80,000 lbs., overhead construction, voltage 6,600).

C. E. VICKERS.

NATURE.

May and June, 1905.

SPECTROHELIOGRAPH RESULTS (*No.* 1,853, *p.* 9).—The pictures produced by this new method of solar research give us photographs of the sun in monochromatic light, or in rays of any particular wave-length that is desired. Thus, if we require to study the distribution of hydrogen on or

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around the solar disc, we employ a line in the spectrum of hydrogen, if calcium a calcium line, or iron an iron line. At South Kensington a stationary solar image is formed by means of a siderostat and lens, and the spectroheliograph is mounted horizontally and moved from east to west across this fixed image, thus securing an easy and uniform motion with perfect steadiness of the solar image under examination. The photographs taken during the past year have been of two kinds, the first, to investigate the distribution and area of the flocculi (or calcium clouds) on the sun's disc, and the second, the distribution and forms of prominences round the limb. It appears that flocculi and prominences are not always interdependent phenomena, but sun spots are always accompanied by a flocculus. In fact the duration of a spot is only a brief interval in the life history of a flocculus. The article is well illustrated with typical cases of spots and flocculi, showing also changes in prominences to a height of 60,000 miles with a velocity of three miles a second. These photographs have been taken with the "K" line of calcium, but other lines in the solar spectrum, such as hydrogen, iron, magnesium, etc., remain to be examined, for which purpose a representative body has been formed to undertake the work and to cope with the large demand of facts relating to our sun.

THE PHYSICAL HISTORY OF THE VICTORIA FALLS.—The origin of the falls has generally been explained by calling in volcanic agency, which caused a crack to be made in the hard basaltic rock from the right to the left bank of the Zambesi, and then prolonged from the left bank away through 30 or 40 miles of hills. Mr. A. J. C. Molyneux, F.G.S., in the *Geographical Journal* for January sketches the geology of the country around the falls and claims that, as at Niagara, the combination of cañon, gorge, chasm and falls is due to erosion and the constant reducing action of the Zambesi river. The falls have checked the deepening of the Upper Zambesi, preventing the Zambesi from becoming a navigable river throughout and markedly influencing the geography of South Africa. *Nature*, No. 1,852, p. 619, gives a good plan and a view of the falls.

SEISMOLOGY.—After the collapse of the campanile at St. Mark's in 1902, there was a popular demand for the cessation of the usual mid-day gun from the fear that its detonation was likely to precipitate the destruction of other historic buildings in Venice. A microseismograph was therefore attached to the wall of the ducal palace, which faces the lagoon and is directly exposed to the sound waves of the cannon; it indicated a vertical displacement, in consequence of the reports, of 0·013 m.m. and a horizontal displacement of 0·01 m.m., being about one-half of those produced by a person jumping on the floor of the room in which the instrument was installed, and one-fifteenth of that caused by a high wind. The sound waves of a cannon have therefore no appreciable effect, though loose plaster may be detached thereby.

THE Japanese advance in MEDICAL EQUIPMENT IN TIME OF WAR is great. Many of the problems which have been the terror of war in European

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countries are stated by Sir F. Treves to have been solved. British troops enter a war expecting to have 10 per cent. of sick, whereas the Japanese are quite content with 1 per cent. of sick, and they get it.—(No. 1,854, p. 11).

ANTARCTIC EXPEDITION.—Its scientific results have been issued in a kind of preliminary report in five papers. There are innumerable glaciers on the coast of Victorialand, but few run back to the inland ice. The Ferrar glacier is typical of the dead glaciers; the ice lies in the valley practically stationary, gradually wasting away from the summer thaw; probably the inland ice stood at one time 500 feet above its present level. It does not make any important contribution to the ice-barrier of the Ross Sea which is probably afloat and in a state of fairly rapid retreat, moving northward at the rate of about 600 yards a year. The expedition collected much valuable material as to climate, the snow-bearing winds were warm, rising to a temperature of 15° C. even in the depth of winter. Biological work could be carried on all the year round, "even with comfort." Animal life is very abundant in the Southern Seas; sponges exist in enormous quantities and a "Nemertine worm was found close on 20 feet long and about the diameter of an ordinary bootlace."—(No. 1,855, p. 57).

THE SEWAGE PROBLEM.—Mr. Martin has provided a book which will be eagerly sought after by members of sewage committees who are appalled by the mass of matter in the numerous blue books published by the Royal Commission. In spite of the great amount of work that has been done, sewage purification is still rather an art than a science, and, on many questions, knowledge is still extremely limited. The Royal Commission has arrived at the conclusion that adequate purification can be effected without land treatment, but no system can be effective without efficient local management.—(No. 1,857, p. 97).

SPECTRO-CHEMISTRY.—Professor Bruhl shows the principles on which spectro-chemical methods of examination can be applied to the solution of many scientific problems, and to the discovery of the chemical structure of single substances, or whole classes of bodies. Research, in the atomic structure of hydrogen piroxide and many other unstable compounds, by purely chemical methods is often difficult and sometimes impossible, because owing to their sensitive organisation, chemical interference leads either to changes in the grouping of the atoms, or even to total decomposition; but by observing the behaviour of light on its passage through these substances, we gain an insight into their structure, without in any way disturbing it. Assistance has thus been rendered to the synthetic preparation of valuable scents, such as ionone, the artificial scent of violets. Special forms of instruments are in use for the examination of fats and oils, milk and butter; the amount of salt contained in salt solutions; the amount of alcohol in beer; the examination of blood and albuminoids in pathological fluids, etc., etc.—(No. 1,859, p. 161).

W. E. WARRAND.

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RAILWAY AND LOCOMOTIVE ENGINEERING.

February, 1905.

SINGLE LINE WORKING.—*Train Staffs.*—The use of the Train Staff system for single lines has not gained much ground yet in America, possibly because the cost of installing the apparatus is an obstacle in the way; the Staff system, as ordinarily used, also entails a stop at every block section to exchange staffs.

We have here an account of certain mechanical arrangements for exchanging staffs without stopping. Such apparatus, adapted for the Webb and Thompson Staff, is in use on some British lines; but the pattern of staff here used (on the Cincinnati, New Orleans and Texas Pacific) is smaller and lighter. It is suspended in a rubber staff case, hung from a delivering arm, and is caught by a "catcher" projecting from the engine. The exhibition of the Train Order signal indicates whether staffs have to be exchanged.

The Santa Fé line uses the train staff on some of its sections, and we have a description of a Permissive Staff system, *i.e.*, electrical staff combined with tickets. The reason for this arrangement is that on the section referred to the balance of traffic, owing to a heavy grade, is all in one direction. Either the absolute staff or permissive staff can be taken out of the same machine, but not both at once. Apparently the train carrying the Permissive Staff may either proceed, follow or go between those having Tickets, which is contrary to our rules; in this country, when Staff and Tickets are used, the driver who accepts a Ticket must always *see the Staff.*

The Absolute and Permissive Staffs are of the same general shape, but one is fluted and the other milled.

A somewhat similar "Tablet and Ticket" ticket is or used to be used on the Midland Railway, between Little Eaton and Ripley (if I remember right).

C. E. VICKERS.

REVUE D'HISTOIRE.

May, 1905.

THE CAMPAIGN OF 1794.—*Army of the North.*—Deals with the proceedings of Pichegru from the time when he took over the command of the army of the north, up to the failure of his attempt on le Cateau, at the end of March.

THE CAMPAIGN OF 1793.—*Army of the North and of the Ardennes.*—This is the beginning of a study of the operations on the Belgian frontier from the surrender of Valenciennes (August 1st) to the Battle of Hondschoote (September 8th), showing how the Allies allowed the initiative to fall into the hands of the French, by sitting down before Dunkirk and Quesnoy.

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The composition and character of the French army is described in great detail.

THE WAR OF 1870–1871.—The movements of the Third German Army are followed from the 13th to the 22nd August. By the latter date it was joined by the newly-formed army of the Meuse, and orders were issued for the march on Chalons. At Chalons 130,000 French troops had been assembled under Macmahon, but how defective this new army was from every point of view is forcibly brought out. To the many shortcomings which had been apparent from the outset in the army of the Rhine, the army of Chalons added want of cohesion, homogeneity, and organisation, and (as regards part of it) want of the most elementary training. It was disheartened and demoralised, and was short of necessaries of all kinds.

June, 1905.

A MILITARY OPERATION OF EUGENE AND MARLBOROUGH.—While Eugene was besieging the citadel of Lille in 1708, and Marlborough was covering the siege, the Elector of Bavaria tried a counterstroke against Brussels. The main French army held the line of the Scheldt from Tournay to Ghent, and the Bruges canal; but the Allies, without raising their own siege, forced the passage of the Scheldt, cutting the French army in two, and obliged the Elector to hasten back to Mons. This is the operation described, and the leadership of the French is contrasted unfavourably with that of the Allies in respect both of skill and harmony.

THE CAMPAIGN OF 1797 ON THE RHINE.—The first instalment of the history of this campaign goes only as far as the surrender of Kehl to the Austrians. Much fault is found with Moreau.

THE WAR OF 1870–1871.—*The Army of Chalons.*—The plan of the Minister of War (Count Palikao) for the advance of Macmahon to the assistance of Bazaine is severely criticised. A movement in Metz might have served an useful purpose if it had been a mere demonstration, abandoned as soon as the Germans gathered to meet it; but arrangements should have been made for falling back eventually on Paris. Without allowing itself to be shut in there, the army of Chalons, 130,000 strong, might have delayed the investment of the city by opposing the passage of the Seine, and should then have retired on Orleans to gather reinforcements.

E. M. LLOYD.

THE TIMES.

Extract from Issue of June 13th.

SPADE WORK IN THE JAPANESE ARMY.—The following report by Capt. P. C. March, General Staff, U.S.A., is of extreme interest:—

"On October 15th, 1904, during the battle of the Sha-ho, I witnessed a practical exhibition of the Japanese use of the intrenching tools carried

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by the men. The 40th Regiment of the 10th Division, 4th Japanese Army, took up a position along the crest of a hill near the River Sha, which marked the furthest position of the Japanese advance at the time, and on the front of the 4th Army. The Russians were visible in force almost immediately in front of us and an attack was expected.

"The companies detailed to construct the trenches came up without arms and squatted on their haunches under cover of the reverse slope of the hill. N.C.O.'s stepped forward from the companies, and threw themselves on their faces on the crest of the hill. They then worked themselves forward by their hands and feet until they arrived at a point where they could see all the ground in the immediate front—no dead space—and put a peg in the ground at that point. The pegs thus established were joined by marking a line on the ground with the point of a pick. The men then came forward, working parties alternating with pick and intrenching spade, the files taking intervals from each other by extending hands at full length, each man covering that much of the line of the trench. While the relief was working the other men of the company remained below the crest squatting on their haunches, and after the first batch had worked about five minutes relieved them. The soil had not been under cultivation and apparently was virgin and hard. The trench, which was 3 ft. by 3 ft., making 4½ ft. cover, was finished in 20 minutes.

"The larger intrenching tools, such as the regular commercial pick and long-handled shovels, were carried on pack ponies with the battalion or regimental train, and were only used when intrenchments and works of a more permanent character were constructed, and when they had plenty of time. There never has been a great war in which intrenchments have been used more than in this war. The whole of Manchuria passed over by the Japanese 1st Army, from the Ya-lu to the Sha-ho, was intrenched, and the army never took a position of any importance without intrenching immediately."

UNITED SERVICE MAGAZINE.

July.

Three articles in this number are on R.E. subjects :—

THE FUTURE OF SUBMARINE MINING, written a year ago under the *nom-de-plume* of "Sic Fidem Teneo," is a careful exposition of the case against handing over submarine mines to the Navy. The best argument used is probably:—"That we have not sufficient trained men for the 'fleet in being.' How then do the Navy propose to detach 2,000 additional men for coast defence work? or is the important work of coast defence to be carried out in a haphazard way by any men who happen to be available?"

MILITARY ENGINEERING IN PEACE AND WAR (With More Particular Reference to Lines of Communication), by Capt. H. E. G. Clayton, R.E.—The writer takes as his text the preface of the *M. of M.E.*, 1903, and

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states how the experience of war has made him modify the types given in that book. He principally advocates the use of very narrow trenches, provided with numerous traverses and "back-cover." Firing Trenches should not be widened to admit of easy communication, but separate trenches should be constructed for communication and drainage and to provide earth for back-cover. These latter trenches should be separated from the fire-trenches by solid partitions of earth. He gives a method of constructing loopholes with the least number of sand-bags possible, also some hints on bridging, roadmaking and the destruction of railways, etc. The last portion of the article is taken up with a somewhat detailed description of the construction of sangars, in which many practical hints are given. The article is profusely illustrated with some ten plans and sections, taken from works actually constructed in the field, and is generally full of tips to officers engaged in such work.

ENTRENCHING AND RANGE-FINDING, by Lieut.-Colonel Alsager Pollock, is principally an account of the Wemyss Multimplement. Colonel Pollock gives the verdict that this entrenching tool is a valuable invention, though in its present form it requires a few small improvements, which, however, could be easily effected.

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RECENT PUBLICATIONS.

Military Operations and Maritime Preponderance, by Colonel C. E. Callwell. (9 × 5½. 15s. Blackwood).

The Peace of the Anglo-Saxons, by Major Stewart L. Murray, with preface by F.M. Earl Roberts. (8 × 5. 2s. 6d. Watts).

History of the War between Japan and China, by the Japanese Imperial General Staff, translated by Major Jikemura and Rev. A. Lloyd. Vol. I. (4to. Tokyo).

The War between the Union and the Confederacy, and its Lost Opportunities, by Brigadier-General W. C. Oates. (8vo. New York).

Geschichte des Schlesischen Pionier bataillons. In dienstlichen Austrag für das Bataillon, bearbeitet von Hauptmann Tiersch.

Festungskrieg. Eine Applikatorische Studie über den modernen Festungskampf. Heft 1. Die Tätigkeit von Angreifer und Verteidiger bis zum Gewinnen der Einschliefsungslinie, von Major Schwarte, Generalstabes. (7 mks. Mittler & Sohn, Berlin).

Infanterie Telegraphen patroiullen, by Oberst Leopold Schleyer. (8vo. Vienna).

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Electric Railways theoretically and practically treated, by Sydney W. Ashe and J. D. Keiley. (8¼ × 5¼. 10s. 6d. Constable).

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Maintenance of Health in the Tropics, by W. J. Simpson, M.D. (2s. 6d. Bale, Sons, & Danielsson).

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Jiu-Jitsu, the Japanese Method of Attack and Self-Defence, by Capt. H. H. Skinner and B. H. Kuwashima. (8 × 5½. 5s. Gay & Bird).

The Native Races of South Africa, by G. W. Stow, edited by G. McC. Theal. (10 × 6. Sonnenschein).

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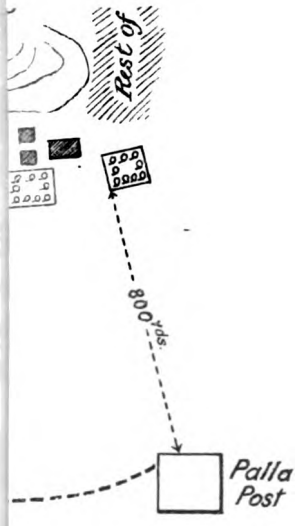

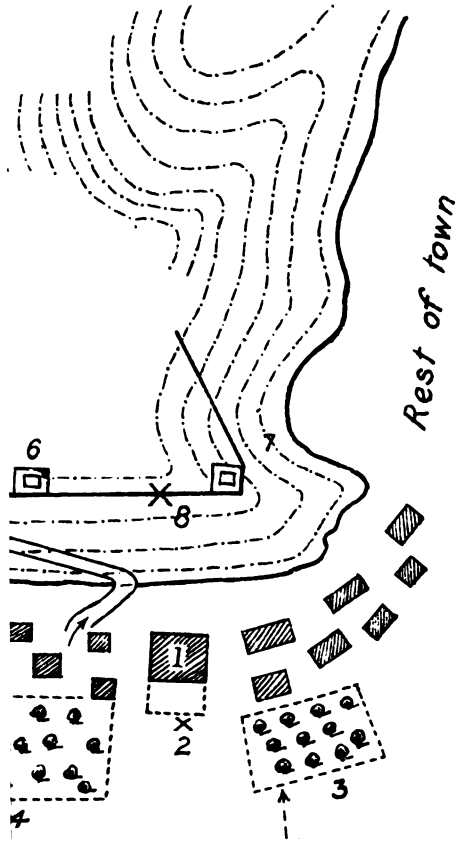

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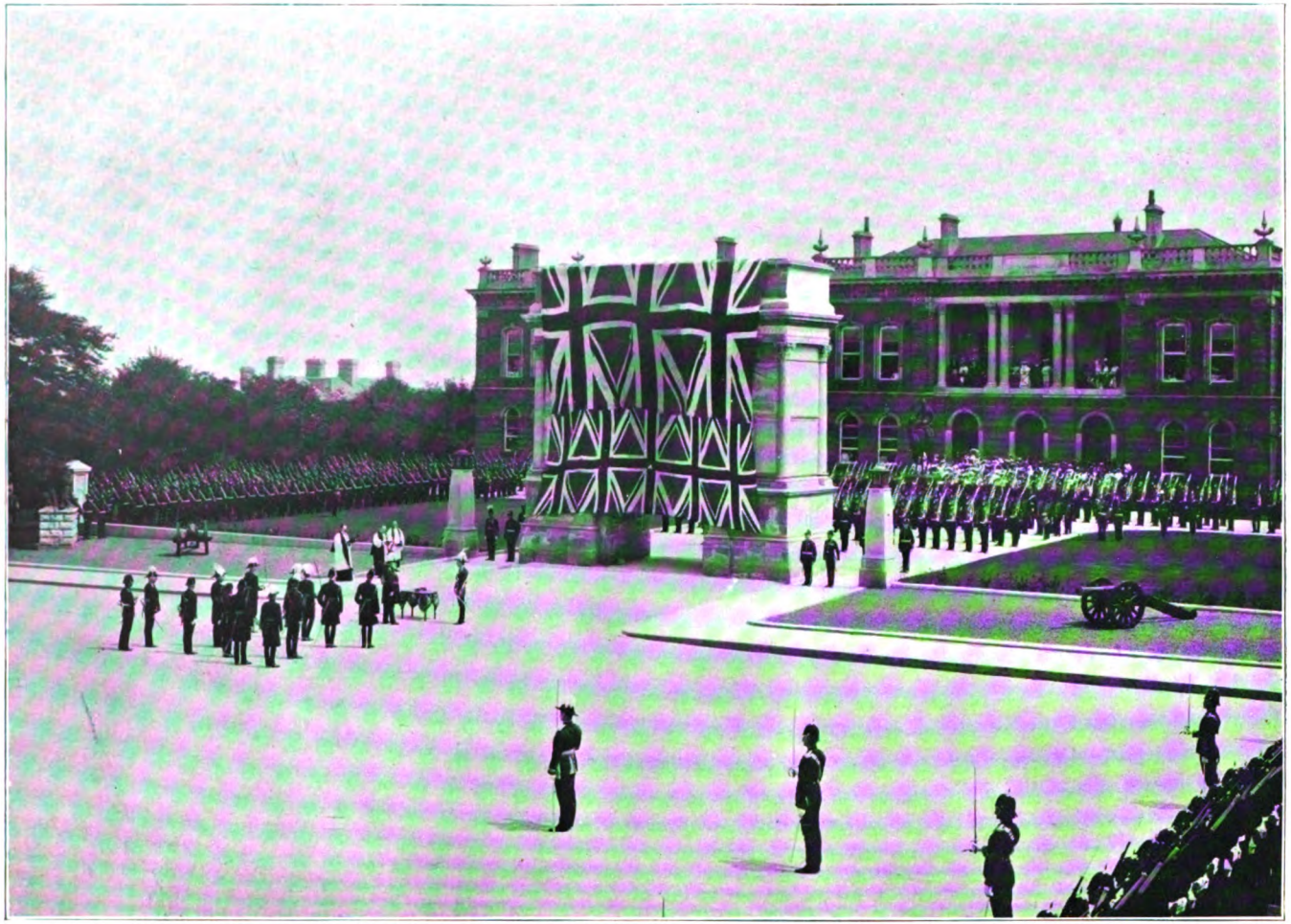

THE ROYAL ENGINEERS SOUTH AFRICAN WAR MEMORIAL.
Lieut.-Gen. Sir Wm. G. Nicholson, K.C.B., addressing His Majesty.

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THE ROYAL ENGINEERS SOUTH AFRICAN WAR MEMORIAL.

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THE R.E. SOUTH AFRICAN WAR MEMORIAL:

UNVEILING BY

HIS MAJESTY KING EDWARD VII., COLONEL-IN-CHIEF.

THE KING honoured his Corps of Royal Engineers by again visiting their Headquarters at Chatham on 26th July, 1905, when His Majesty unveiled the Memorial Arch erected by them in memory of their comrades who lost their lives in the War in South Africa, 1899—1902.

DESCRIPTION OF THE MEMORIAL.

The decision as to the form the memorial should take was entrusted to a Committee elected at the Annual Corps Meeting of 1903 and consisting of the late Lieut.-General Sir Robert Grant, G.C.B., Major-General Sir Elliott Wood, K.C.B., Colonels Robert H. Vetch, C.B., R. H. Jelf, C.M.G., W. Pitt, and H. W. Smith-Rewse, C.V.O., Lieut.-Colonel J. Winn, and Major A. T. Moore (*Hon. Secy.*). After consideration of other proposals a design by Mr. E. Ingress Bell, F.R.I.B.A., for a triumphal arch was selected.

In preparation for the proper display of the memorial a square or "Place" was formed between the inner parade of Brompton Barracks (on the side where stands the Crimean Arch) and the forecourt of the Royal Engineers Institute, the enclosure of the latter being set back to accord with the retired centre of the Barrack enclosure. In the centre of this new line of enclosure and immediately opposite the Crimean Arch the new memorial has been built. In the four re-entering angles of the "Place" the large bronze statues of Boers, lent by Lord Kitchener, have been temporarily erected on suitable pedestals, and Burmese guns have been placed on the flanks of the new arch.

The main fabric of the new arch is Portland stone of specially selected quality. A principal feature of the structure is a series of sculptured panels in high relief, showing:—(*a*) A typical blockhouse with barbed wire defences, telegraph lines, and accessories; (*b*) A movable ox-wagon blockhouse; (*c*) A pontoon bridge with a team of wagons crossing it, and a military balloon in the background; (*d*) A destroyed railway bridge, with an armoured train running over a diversion in the bed of the river. All these have an historical value inasmuch as they are based upon photographs of actual incidents and scenes. Two more similar panels, representing Paardeberg and

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Wagon Hill—where the Engineers particularly distinguished themselves—are required to complete the series; and for these it is hoped that the necessary funds will eventually be forthcoming. A large panel above the Arch, on the Barrack side, bears the dedicatory inscription

THE CORPS OF ROYAL ENGINEERS
TO THEIR COMRADES WHO LOST THEIR LIVES
IN THE SOUTH AFRICAN WAR. A.D. 1899—1902.

The frieze which runs round the base of the attic is of Istrian marble, and inscriptions filled in with lead give the names of the sixteen actions for which clasps were awarded with the war medals. The broad piers at the abutments of the arch have Istrian marble tablets on which are recorded in leaded letters the names of the Officers, Warrant Officers, Non-Commissioned Officers and Men (420 in all) of the Regular, Militia and Volunteer Engineers who lost their lives in the war. On one of the inner faces of the archway a small marble tablet gives the titles of the various units of Engineers that served in the campaign; and His Majesty the King has graciously approved of a companion tablet on the opposite wall, to record the fact that the unveiling ceremony was performed by himself as Colonel-in-Chief of the Corps.

The alto-relievos are by Mr. W. S. Frith. The composite capitals to the columns, the keystones of the arch (figures of victory), and the spandrels containing representations of the medals for this campaign are the work of Messrs. Fagan & Bell. The marble tablets with leaded inscriptions are by Messrs. Farmer & Brindley, and the copper lamps on the detached pillars are by Messrs. Thos. Elsley & Co. The general contractors were Messrs. Longley and Co., of Crawley, Sussex.

The cost of the memorial (about £2,750) has been met by subscriptions from all ranks of the Corps, Regulars, Militia and Volunteers, and by donations from relatives of deceased officers and from gentlemen who served with the Engineers during the campaign.

THE UNVEILING CEREMONY.

At the request of the Memorial Committee and of the Colonels Commandant, Major-General Sir Reginald C. Hart, V.C., K.C.B., K.C.V.O., Commander, Thames and Medway Defences, and Commandant of the School of Military Engineering, undertook to make all the arrangements for the unveiling ceremony; and a local Committee was appointed which, beside Sir Reginald Hart, included Colonel G. R. R. Savage, Chief Engineer, Thames and Medway Defences, Colonel H. W. Smith-Rewse, C.V.O., Assistant Commandant, S.M.E., Brevet Lieut.-Colonel A. W. Roper, President, Headquarter Mess, Brevet Lieut.-Colonel G. M. Heath, D.S.O., Instructor in Fortification,

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S.M.E., Major A. T. Moore, Hon. Secy., Memorial Committee, and Major G. H. Harrison (*Hon. Secy.*).

On arriving at the site of the Memorial His Majesty, who was accompanied by His Royal Highness the Duke of Connaught, Inspector-General of the Forces, and attended by Lieut.-General Hon. Sir Neville G. Lyttelton, K.C.B., Chief of the General Staff, and two Equerries, was received with a Royal Salute by all the Royal Engineers in the Thames and Medway Defences Command. The troops, who were drawn up on the north and south sides of the "Place" and in front of the Institute, were under the supreme command of Major-General Sir Reginald Hart.

Lieut.-General Sir William G. Nicholson, K.C.B., as the Senior Royal Engineer Officer on the Active List present, then addressed His Majesty as follows :—

> May it please Your Majesty,—It is my privilege to be deputed on behalf of your Corps of Royal Engineers humbly to ask Your Majesty to be graciously pleased to unveil and open the Memorial Arch which we have erected in memory of our comrades who lost their lives in the South African War; and also to convey to Your Majesty our deep appreciation of the signal favour which you, Sir, our august Colonel-in-Chief, have bestowed upon us by coming to our headquarters for this purpose.
>
> From time immemorial it has been thought fitting to accord special honour to those who have died in the field in the service of their Sovereign and country, and no higher honour could possibly be conferred on the memory of our comrades who lost their lives in South Africa than Your Majesty's presence here to-day.
>
> And while this memorial ceremony recalls the incidents of the past—long marches, hot engagements, days of danger, nights of waking—it should also serve to remind us, Your Majesty's soldiers, of the obligations of the future. It should tend to animate and inspire us with that ancient heroic spirit which the history of former wars, and especially the history of the present war between Japan and Russia, clearly shows to be of at least as much value in the field of battle as the strictest discipline and the most perfect training. I mean that spirit of self-sacrifice, based on loyalty and patriotism, which regards ease, comfort, material advantage, family ties, life itself, as of no account whatever when compared with the claims of duty and honour. This is the spirit which, we believe, animated our comrades who fell in South Africa. This is the spirit which actuated our predecessors in the Naval and Military Forces of the British Crown who fought and won the battles by sea and land which established and extended Your Majesty's Empire; and it is only if imbued with the same spirit that we can hope, when next we have the honour of serving Your Majesty in the field, to emulate the deeds of our predecessors, to show ourselves worthy of our late comrades, and to do our duty to our King and country.

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The King in reply said :—

> I have very great pleasure in coming here to-day to unveil this Memorial in memory of fallen comrades, and I am proud to be associated with the Corps of Royal Engineers. I am well aware of the courage and devotion to duty which the Royal Engineers have always shown in the past, and I feel confident that they will maintain their high reputation in the future.

His Majesty then closed an electric switch, which was in circuit with detonators attached to cords connecting the Union Jacks draped over the faces of the arch. The cords being severed by the exploding detonators, the flags fell gracefully to the ground.

The arch being unveiled the Royal Engineers on parade Presented Arms, and the ceremony continued as follows :—

Chopin's *Marche Funèbre* by the Band.
Three volleys by the Firing Party, each followed by a few bars of the "Dead March" from *Saul*.
"Last Post" by 12 Buglers.
Verse of Hymn *Onward Christian Soldiers* by Children of the Corps.
Dedicatory prayer by the Chaplain-General.
The Blessing by the Chaplain-General.
"Reveillé" by the Buglers.

On the conclusion of this extremely dignified and very impressive ceremony, His Majesty was graciously pleased to plant an evergreen oak tree in the grounds of the Institute, and to be photographed with the senior officers of the Corps.

The King subsequently presided at luncheon in the Royal Engineers Mess. The senior officers present were :—Generals Sir Horace Montagu, K.C.B., Sir Harry Prendergast, V.C., G.C.B., and Sir Richard Harrison, G.C.B., C.M.G.; Lieut.-Generals Gordon Pritchard, C.B., Sir William Nicholson, K.C.B., and E. P. Leach, V.C., C.V.O., C.B.; Major-Generals Hon. G. Wrottesley, Renouard James, Sir Thomas Fraser, K.C.B., C.M.G., Sir Harry Settle, K.C.B., D.S.O., Sir Elliott Wood, K.C.B., D. A. Scott, C.V.O., C.B., D.S.O., and Sir Reginald Hart, V.C., K.C.B., K.C.V.O.; Brig.-General H. M. Lawson, C.B., A.D.C.; Colonels G. Barker, C.B., G. R. Savage, W. Pitt, R. M. Ruck, C. A. Rochfort-Boyd, C.M.G., H. L. Jessep, H. W. Smith-Rewse, C.V.O., R. Maxwell, C.B., G. H. Sim, C.B., and W. F. H. Stafford, C.B.

(A more detailed account of the ceremony, with additional illustrations, has been published as a Special Supplement of foolscap size.—EDR.).

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A SHORT SKETCH OF NAPOLEON'S CAMPAIGN IN ITALY, 1796–97.

By LIEUT. W. HYDE KELLY, R.E.

NAPOLEON'S first plan of campaign,—the invasion of Italy in 1796—was conceived by him before there was any thought of the chief command of the "Army of Italy" being entrusted to him. He had carefully studied the situation, thought out its possibilities, weighed his chances, and assured himself that there was no other soldier capable of executing the plan.

With characteristic self-confidence he sent in his scheme to the Directoire, and it found favour with Carnot. General Schérer, who at that time commanded the French army in Italy, had wasted his opportunities and made no progress; and the Directoire felt that the young general, of whose energy and forceful ability they already had had evidence, would fit the command and bring new life into the war.

It was on 21st March, 1796, that Buonaparte set out on his first campaign—confident in his own ability, and fired with his own ambition.

Northern Italy was overrun by the Austrians. The Austrian and Sardinian (Piedmontese*) forces, numbering together 52,000 men, under the command of Beaulieu and Colli respectively, held the junction of the Apennines and Maritime Alps, and the adjacent passes. The Sardinians were based on Turin, the Austrians on Milan; and the roads leading through the valleys of the Bormida and Tanaro supplied good communications with these cities. But the forces were divided into detachments to guard the passes, and the inter-communication between these was difficult.

Buonaparte's army, 42,000 strong, reinforced before the first engagement to 49,000, was based on Nice. His plan was to endeavour to thrust apart the Austrians and Sardinians, driving the former back on Milan, and the latter on Turin; and then, holding the Austrians, to compel the Sardinians to come to terms. The leading idea was precisely that which Napoleon conceived when he formed his plan of campaign in 1815. He knew that the point of junction between the two forces was the weakest spot, and he accordingly made for that point.

At the beginning of April, 1796, Buonaparte concentrated his forces at Savona; and, with the idea of drawing the attention of the Austrians, pushed a brigade as far as Voltri, so as to threaten Genoa. Now the French line of communications was strategically in a very dangerous position: Buonaparte's front was actually parallel to his

* Sardinia and Piedmont were at this period united under one crown.

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communications with his base. But his enemy could not attack through the mountain passes in any large numbers, and it was this fact alone which made the French positions possible.

Beaulieu, fearing that a strong movement was about to be made against his left, sent off a large detachment towards Voltri, where the French brigade was met. This was exactly what Buonaparte's plan required. The Austrian commander, always hampered by imperative orders from Vienna, commenced the attack all along his line, but his main efforts were directed against Voltri. Argenteau, commanding the weakened Austrian centre, attacked a French detachment posted on the slopes of Monte Legino; but the defence was stubbornly maintained until Buonaparte, on the next day, brought up strong columns under cover of a mist to assault the Austrian position.

At Voltri, meanwhile, the French brigade was driven in by Beaulieu with some loss. The attack on the centre was vigorously pressed, but the Austrians made a fine defence. Masséna, moving against their right flank, drove them back in disorder; their crumpled wing, falling back on the centre, compelled the rest to give way, and the whole line fled precipitately. This was the deciding movement of the campaign. It forced the Austrians in a north-easterly direction, and away from their allies the Sardinians, who meanwhile were held back by demonstrations from Ormea and Garessio, on their right flank.

The Austrians, not wishing to lose Lombardy, fell back towards Milan. At Millesimo, a village on the right bank of the Bormida, they endeavoured to make a stand, but Buonaparte vigorously attacked, and they were driven back with a loss of 1,200 men. They then fell back to Dego, a village on the road to Milan, which they had strongly entrenched. Here Masséna again turned their flank, and drove them back; but at the dead of night, 3,500 Austrians surprised the French troops pillaging the houses, and recaptured the position. Here was Beaulieu's opportunity to retrieve his fortunes. He should have rallied and brought up more troops, with which the surprise could have been turned into a serious disaster for the French. But he was an old man, past the energy requisite in a general in such a position; furthermore, he was hampered by absurd instructions from Vienna, and the results were the natural consequences of such evil control.

Buonaparte, on the other hand, enraged at this unexpected check to his triumphal march, threw his whole energy into the situation; and with his marvellous grasp of circumstances, hurried fresh troops to the attack, which was renewed next morning with vigour. The five battalions of Austrians, who had dared the surprise, were driven out with loss, and Dego was once more in the hands of the French.

On the west, the Sardinians, now hopelessly separated from their allies, withdrew to a strong position at Ceva, where they successfully checked the French for a time. But their situation was no better than Beaulieu's at Dego; and neither force could help the other.

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Buonaparte hurried up with two French divisions, and Colli retreated towards Turin, the Austrians, in their turn, being prevented from offering any assistance by a French division at San Benedetto and a brigade at Cairo.

Thus in four short days, Buonaparte had brilliantly carried out the first part of his plan of campaign. He had wedged himself in between the allied armies, and defeated each in turn. He had, furthermore, prevented all possibility of their junction south of Milan and Turin. He had, in fact, accomplished successfully in his first campaign what he so nearly succeeded in doing in his last. Had his enemies of 1796 possessed the greater qualities displayed by Wellington and Blucher, he might have suffered defeat at the very outset of his brilliant career. But Beaulieu was no Blucher, and Colli's Sardinians thought only of Turin. Buonaparte knew his opponents' characters and acted upon his knowledge.

Negotiations for peace were now opened between Turin and Paris. Buonaparte, through whom all the preliminaries were arranged, stipulated for the surrender of three important strongholds—Alessandria, Tortona, and Coni—as the primary conditions of peace. These fortresses at once gave Buonaparte a great strategical advantage, and enabled him to transfer his line of communication with France from Nice and the coast to the route through Monte Susa to Turin. This line was both shorter and safer; for now, in his further operations against the Austrians,—who, although deserted as they believed by their allies, were by no means disposed to let Lombardy go,—his front would be perpendicular to his line of communications. The fortresses also gave him a new base of operations. All this was the outcome of a sound application of the first principles of strategy. At the very beginning, the dispersion of the allies, and their inability to securely hold their extended front, offered a tempting object to a vigorous young general of Buonaparte's intellect. Secondly, the mountainous country screened the movements of the French. Thirdly, there was no real cohesion, no subordination of their movements, in the allied armies. Fourthly, the position originally held by the Austro-Sardinian armies was a weakness in itself, owing to the entire lack of lateral communication. These were defects which would at once attract the attention of an able opponent, and Buonaparte was not the man to lose sight of them.

To return to the coming campaign against the Austrians. Their shattered army had withdrawn beyond the Ticino; and, taking up a strong position at Pavia (where the road from Genoa to Milan crossed that river), with detachments patrolling towards Valenza and Piacenza, they awaited the attack of the French.

In the rich plains of Lombardy, Beaulieu expected to be able to use his superior cavalry with effect, but he was so completely outmanœuvred by his able opponent that he had no chances of realising

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his hopes. Moreover, a general who has been beaten back in continuous rout, and who has not had time to revive his demoralised troops, cannot expect his forces to suddenly become excellent fighting material; every defeat deprives him of any power of manœuvring that he may hope for. With Buonaparte, on the other hand, the troops were young, and flushed with the joys of victory; worshipping their brilliant commander, and eager to be led to further glory. All this moral influence counts heavily in the stress of war, and the backbone was gone from the Austrian resistance.

Buonaparte, always well-informed of his adversaries' whereabouts, chose Piacenza as his point for crossing the river Po; and in order to delude Beaulieu, he demonstrated towards Valenza. His real advance was from Tortona. He pushed rapidly with his main force to Piacenza, where Lannes, crossing by the ferry, drove back a small party of Austrian cavalry, and the troops poured across the river. Beaulieu, aroused too late, sent off 5,000 men, under Liptay, to strengthen his left; but Liptay, meeting practically the whole force of the French, was speedily crushed, and withdrew eastwards in the only direction left to him. Here again Buonaparte's fine strategy forced apart the enemy's columns. Beaulieu, coming up later with his main body, met a similar fate at Fombio, and, thoroughly beaten, drew off to Lodi, where there was a bridge over the Adda. Here was another masterstroke; Milan was thus exposed without defence.

But Beaulieu, who saw that a retreat across the Adda would still give him chances of further resistance if he did let Milan go, still had a force which, although shattered beyond hope of immediate recovery, was a danger in the rear of an army.

On May 10th Buonaparte seized the bridge at Lodi, the possession of which a small rearguard of Austrians hotly contested. Beaulieu retired behind the Mincio and rallied his crumbling forces behind the walls of Mantua. The next phase of the campaign resolves itself into a series of struggles for the possession of that fortress.

The Austrian position at Mantua was of great strength; and as reinforcements were promised from the Tyrol, Beaulieu still had hopes of a turn of the tide. Buonaparte, too, gave him a respite by halting to settle the affairs of the newly-conquered territories and to refill the Paris treasury-chests with heavy indemnities in cash and in kind from the ancient cities of Turin and Milan.

In May, Brescia, although in Venetian territory,—which was then neutral ground—was seized by Buonaparte as a punishment to the Venetians for permitting Austrian troops on their soil; and the possession of this town gave the French an important advantage in the future operations for the capture of Mantua. The strategical situation had indeed reversed itself, for now Beaulieu's communications with the Tyrol ran parallel to *his* front; and Buonaparte at once took advantage of this fault. He threatened the enemy's positions on the

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western bank of the Adige ; and caused the Austrian general to weaken his centre, by despatching troops to guard Rivoli, to such an extent that Lannes, crossing the Mincio at Borghetto on the 30th May, easily forced the Austrians from their positions, from which they withdrew to the northern valley of the Adige, leaving a garrison in Mantua.

Here was " the beginning of the end " of the Austrian resistance ; for, Masséna having been sent to hold them in the Adige valley, Buonaparte was able to close round Mantua, which had been freshly provisioned by Beaulieu just before his retirement northwards.

Beaulieu's last retreat took an extremely perilous direction, although it was along his line of communications. A beaten general retiring along a line parallel to his enemy's front is in the very worst strategical position ; and it is a matter of some wonder that Buonaparte did not push home his attacks on Rivoli —(which, it will be remembered, were the cause of the weakening of Beaulieu's centre),— attacks which would have taken the Austrians in the rear, or at least in flank. But against this it must be remembered that Buonaparte's forces were none too large for the work in hand. His great length of communications needed secure guarding, and he had scarcely sufficient men to invest Mantua.

The Emperor of Austria, determined not to lose Italy, now put forth fresh efforts to drive out the invader. He could not afford to let Buonaparte advance and unite with the French armies from the Rhine ; Vienna would be too seriously threatened. Moreover, the French (he supposed) were widely scattered, and were rapidly losing their reputation, and suffering in *morale* through endless plundering in the conquered cities. Towards July, 1796, he appointed Wurmser in place of Beaulieu, and gave him another 25,000 men, which he detached from his forces on the Danube. With the shattered fragments in Italy Wurmser's troops now numbered 48,000, and with these he was ordered to relieve Mantua and repel Buonaparte.

His task seemed to offer very fair chances of success. His enemies were widely dispersed, both for subsistence and plunder, and their long line of communications swallowed up a great many troops. The presence of the garrison in Mantua could also be reckoned upon to impede their movements. The way in which Buonaparte extricated himself is highly instructive.

Wurmser, compelled by the narrowness of the valley through which he advanced to separate his columns, committed a great strategical blunder by sending Quosdanovitch with 18,000 men down the western side of Lake Garda to seize Brescia and cut Buonaparte's communication with France. This move, although its success would have seriously hampered the French, was extremely hazardous for the Austrians, for Quosdanovitch's force would be completely cut off by the Lake from Wurmser's main body, which, consisting of 24,000 men, was to advance down the valley of the Adige and attempt to relieve

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Mantua. Davidovitch, with another division of 5,000 men, was sent from Fiuli towards Vicenza to threaten the French right. The Austrians seemed fond of dispersing their forces in the face of the enemy without the means of uniting them on the field of battle. However successful the main body might be, neither of the detached forces under Quosdanovitch and Davidovitch could offer assistance or expect assistance. The plan entirely ignored the lessons so recently learned at the hands of Buonaparte.

Towards the end of July, the Austrians advanced on the French positions, drove in the outposts at Rivoli, and threatened Buonaparte's communications by their move on Brescia. The latter, at once realising the situation, ordered his scattered forces to concentrate on the centre, at the south end of Lake Garda. Here he could attack either of the Austrian columns, and still cover the siege of Mantua. His strategy was very different from that of Wurmser.

But when Brescia fell into the hands of the Austrians on July 30th, he ordered Sérurier, who was besieging Mantua with one division, to withdraw westwards, destroying his guns if he could not save them. He now saw that it was of more importance to defeat the armies in the field than to attempt the capture of a stronghold, the possession of which could not be used to full advantage until those armies were disposed of. Augereau, strengthened by a part of Sérurier's division, recaptured Brescia on August 1st; and the main French force fell back behind the Mincio. Wurmser, following up, fully believed that Buonaparte was retreating at last; and when the important point of Castiglione fell into his hands, he thought he had triumphantly broken the French centre. But Buonaparte entrusted the recapture of Castiglione to the dashing Augereau, who carried out his task with great vigour. This was a serious check to Wurmser, who now had not only lost the ground he had gained but also the chance of joining hands with Quosdanovitch on the west of the Lake.

An attack on Masséna at Lonato met with some success at first, but Buonaparte came up with reinforcements and drove back the Austrians, who withdrew in confusion. The French now pursued, and the beaten enemy were roughly handled in their rush towards the southern end of the Lake. Acting once more under rigid instructions from Vienna, Wurmser confronted the French in a strong but attenuated position, stretching from Médole to Solferino; but his anxiety to lend assistance to, and join hands with, Quosdanovitch so weakened his centre and left that Marmont rolled up this flank, while Masséna and Augereau charged the centre. On his left, Buonaparte had skilfully "refused" and had kept his divisions slightly withdrawn to lure on the Austrian right. The result was the total defeat of the Austrians. It was a conflict of manœuvres rather than a soldier's battle. Buonaparte's skilful moves against Wurmser's left, while he purposely weakened his own left, could not

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be met by the Austrian dispositions. Once their left was engaged, any attempt on the part of their centre to change front was prevented by the divisions under Masséna and Augereau.

But in spite of this defeat Wurmser still had the advantage. He had so far succeeded in his plan as to relieve Mantua, for the time being, and he had also captured Buonaparte's siege-train (Sérurier's retreat). The French general, moreover, was prevented from advancing through the Tyrol to join Moreau, with whom Buonaparte desired eventually to march on Vienna. But the Austrians had suffered in battle losses far more severely than the French.

At Bassano Wurmser lost many more men at the hands of Masséna, who pursued him hotly; but, turning at bay, he managed to get into Mantua where he could rally his troops. A short respite followed, during which Buonaparte strengthened his position in the newly-conquered states behind him; and Austria, gaining great victories over Moreau and Jourdan on the Rhine, poured more troops into Northern Italy and again changed the command from Wurmser to Alvinzi, a veteran with an honoured name but no strategical skill.

Alvinzi promptly marched westwards, with his forces more or less concentrated, and took up a position at Caldiero, east of Verona, where Buonaparte's army was assembled. On November 12th, the French attacked, but so skilfully did the Austrians dispose their guns that the attack was repulsed with heavy loss. Buonaparte withdrew to Verona; and it seems as if the tide of French victory was about to turn at last. Making another attempt against Alvinzi's position on the 15th, Buonaparte secretly sent the divisions under Masséna and Augereau to Ronco, on the right bank of the Adige and south-west of Verona. Here a bridge of boats was thrown across, and the French columns passed rapidly over, Augereau making for Arcola to take the Austrians in rear and Masséna moving up towards Caldiero. At Arcola, however, some Austrian troops, despatched by Alvinzi, checked the advance and, being rapidly reinforced, drove back the French divisions. On the following day, the French gained ground, but were still vigorously opposed by Alvinzi's left wing, where his troops fought splendidly. In the third day's fighting a ruse gave Buonaparte the victory. A small detachment of cavalry was placed behind a hill, and a fierce blare of trumpets sounded the charge. The simultaneous appearance of a few troops in rear of Arcola caused the Austrians to flee panic-stricken, and the position at Caldiero was won.

On the Austrian left, Davidovitch had gained some success at Rivoli, but Alvinzi had neglected to keep his subordinates informed as to the general situation and to gather information for himself; consequently a grand opportunity had been missed. While the French were checked at Arcola, why did not Wurmser move out against their rear from Mantua? or why did not Davidovitch press his attack on the right? Because neither of his subordinates knew

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anything of Alvinzi's position. Ignorance, in this case, was paid for very heavily. There was no cohesion or unity of movement among the separate Austrian columns. Failure was bound to ensue in the face of so skilful and vigorous a foe as Buonaparte, who had thoroughly studied the moves of war and practically applied the principles of strategy in each case as it arose. He had not read history for nothing.

Now followed another respite while Buonaparte was engaged in affairs of diplomacy.

At the opening of 1797, the Emperor Francis of Austria made a further and last effort to relieve Mantua and save Italy. Still the council at Vienna drew up rigid plans for their Commander in Italy. The plan now formed was briefly :—Alvinzi was to join forces with a column advancing from the Tyrol, drive the French out of Rivoli, and force them back on Mantua ; Provera with 9,000 men was to advance from Legnago ; and another force of 10,000 was to attack the French at several points along their front. Here again was the fatal error of dispersion. The Austrians clung obstinately to their favourite plan of endeavouring to envelope their enemy, and Buonaparte once again saw his opportunities.

At first the French were in doubt as to which was the enemy's real line of advance, but reconnaissances soon removed the difficulty. It was at Rivoli that the main blow would fall. Here there were 10,000 men under Joubert. But the rapid advance of the Austrian main body was discouraging the French, whose commander, though a man of great bravery, was already thinking of falling back when Buonaparte hurried up reinforcements and, in the nick of time, saved the strong position.

Situated on the western bank of a very sharp bend in the Adige, the village of Rivoli offered a very secure position against a force advancing from the north. Steep mountains close in the bend of the river, but on their north-western side a gentle slope falls to the valley of a small stream called the Tasso. Across this again is the height of Monte Baldo, whose spurs jut out into the little valley. On the western bank of the Adige runs the road leading from Verona to Trent, but north of Rivoli this road runs down the slopes and along the river. It was an ideal position, as any attack along the river would be easily repulsed by a determined defence on the heights ; and an attack from the north-west, from Monte Baldo, would require a very large number of men, whilst a small force would suffice for the defence. Certainly the position could be turned by a wide flanking movement on the west, and this was, in fact, partly what Alvinzi attempted to do ; but his numbers were too small and his tactics too faulty to ensure success.

The Austrians, numbering 28,000 men, found it an easy matter to drive in the French outposts, Joubert having only 10,000 troops all told. So threatening was the situation that Joubert was preparing to retreat ; but Buonaparte hastened up with reinforcements during the

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night and, making an attack on the Austrians then and there, he recovered the lost ground.

The Austrian plan of attack took the old form of an attempt to envelope the enemy. No less than six columns were to attack the French. One was to move up the eastern bank of the Adige and bombard the heights at Rivoli—a dangerous move, for by no chance could any close communication be kept up with the remaining five columns; another, with the rest of the artillery and cavalry, was to take the road along the western bank and try to assail the French in rear; three were to attack frontally; and the sixth and last column was to make a wide detour and attack the enemy's left flank. The practical impossibility of keeping up inter-communication between these separate bodies was the chief cause of failure.

In the battle that followed the column on the east did little more than make a noise with its artillery. The column moving up the winding river-side road was received with a very hot musket-fire as it ascended the steep slopes. The three bodies attacking from Monte Baldo, although at first very nearly successful, were afterwards assailed by Masséna's fine troops with a charge of French cavalry to support them; some of the Austrian troops receiving the charge, broke and fled, shouting to their neighbours to save themselves; the panic, once started, soon spread, and all fear of a fresh assault from the direction of Monte Baldo was dispelled. But the westernmost column of the Austrians worked their way cleverly round, and threatened to fall on the French rear; there was, for a time, great consternation even among Buonaparte's best officers, but at the right moment reinforcements arrived from Verona.

The other attacks having failed, Buonaparte could afford to give most of his attention to the position of affairs in his rear, with the result that the last Austrian column was beaten back with loss. This was the end of the battle; Alvinzi, hopelessly beaten like his unfortunate predecessors, fell back into the Tyrol.

The battle ought never to have been lost by the Austrians. If the western column had timed its attack on the French rear to fall simultaneously with the attacks from Monte Baldo and the river road, even Buonaparte could scarcely have avoided defeat; for there was no retreat left to him. Reinforcements from the south could have made their attack much more difficult for the Austrians, but the western column should have carried out its plan before such reinforcements could arrive. Further, Provera was working his way successfully towards Mantua, and the French forces south of Rivoli would have had their work cut out to avoid being taken in rear themselves. As it was, Buonaparte, after despatching Joubert in pursuit of Alvinzi, hastened back to Augereau in the south, fell upon Provera's army near the walls of Mantua, and destroyed it completely (January 16th, 1797). Mantua fell on February 2nd, when Wurmser surrendered with 20,000 men.

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This ended the campaign of 1796—1797 in Italy. It is an interesting campaign in a number of ways. It was the first undertaken by Buonaparte, and also the first since Frederick the Great's time in which the principles of strategy were soundly applied. It was the first, too, in which the new spirit of republicanism fired the French soldiery. It was the dawn of a great career.

In nine months Buonaparte, who had begun with a reputation for skill in artillery matters only, obtained for himself the position of foremost general in Europe. He had begun the campaign with a small base and a hazardous line of communications along the coast from Nice to Savona; and he had pushed his front northwards and eastwards until he had behind him a secure line of communications with France and also a number of strong cities and fortresses—Turin, Milan, Tortona, Alessandria, Coni—which he used as an advanced base for his operations against Mantua.

He always kept his forces concentrated for fighting, and he often knew more about the enemy's position than they did themselves. He was backed up by brave and intelligent subordinates, and his troops were as enthusiastic for him and the glory he gave them as they were for the new spirit of republicanism.

The campaign shows the great influence of an initial success leading on to further triumphs by the inspiration given to the victorious army. Had Buonaparte's troops suffered defeat at the outset, their *élan* might have died out, and nothing but a great victory can restore nerve and discipline to demoralised troops. But Buonaparte led victorious troops to fresh victory, and against him he had an enemy weakened and demoralised by continual defeat.

The Austrians failed:—(1) because the great mountain barrier of the Tyrol separated their armies from their ultimate base; (2) because all their plans of campaign and movements in the field were dictated by a council sitting in Vienna, nothing being left to the commander on the spot; (3) because none of their generals had made a proper study of war; (4) because the Italians were anxious to try the new republicanism.

The war continued after the fall of Mantua, but it became a procession of triumphs towards the heart of Austria; although the Archduke Charles, one of the ablest generals his country has produced, took command to retrieve his nation's honour. His shattered and broken-spirited troops could not withstand the advance of the victorious French, gaining in glory with every fresh triumph. An armistice was declared at Loeben, almost within sight of Vienna, and peace was afterwards signed at Campo Formio. Austria gave up Belgium, the Ionian Isles, and her share of Bresgau; she gained the greater part of the Venetian territories, as well as Istria and Dalmatia, strips on the coast of Illyria.

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*MILITARY EDUCATION IN THE UNITED STATES OF AMERICA.**

By Bt.-Colonel H. J. Foster, *p.s.c.*, R.E., *Military Attaché at Washington.*

Education has always been a cherished ideal of the American, who is rather inclined to regard its processes with an almost superstitious reverence and perhaps to exaggerate its effect. States and Cities, Counties and Townships, vie with each other in the extent and elaboration of the educational facilities provided for their sons and daughters. In the Philippines for instance the formation by methods of American education of a higher type of citizen, ripe for self-government, has been the leading idea of the administration of the islands; and this, moreover, to the neglect—until recently—of the more practical needs of improved communications and public works.

In the military world, this ideal, which a hundred years ago was responsible for the founding of an admirable military school at West Point, has recently developed a complete scheme of military education, covering the whole ground from the instruction of the private to that of the officer of the General Staff and even of the General. In this curriculum the technical officers of the Engineers, of the Coast and Field Artillery and of the Submarine Mining service have not been overlooked.

For the Privates there are "Post Schools," where the ordinary primary education of civil life is given, with some algebra and trigonometry for advanced pupils.

For Non-Commissioned Officers there are schools in each battalion and squadron, as well as in the artillery. In these the instruction is given by selected officers through the medium of lectures, problems for solution, and practical exercises. The subjects include :—Army regulations affecting the men, the drill of their arm, simple tactics, hasty sketching and reconnaissance. Mounted men are also taught "Hippology," by which useful word is meant a general knowledge of horses, the art of good horsemastership, and veterinary science. Lectures are given on the history of the Pupils' Corps and its achievements in war; and when practicable Spanish is taught.

As regards Officers, it must be explained that the supply is derived from several sources. Besides the influx every June of some 60 to 90 cadets from the Military Academy at West Point, commissions are granted to candidates from the ranks or from civil life, who pass a

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qualifying examination. During or shortly after a war this latter method of entry is largely taken advantage of by officers and men from the volunteers enrolled for that war. Although the examination includes the elements of history, algebra, geometry, trigonometry and topography, as well as a knowledge of the Constitution and of International Law (and not one half of the candidates as a rule are successful), these officers of course have not the education or training of the West Point Cadets. For their benefit therefore, there has been established a system of Garrison Schools throughout the country, at which all Lieutenants and Captains under ten years' service must attend until they have passed. West Point Officers are excused attendance at the "Recitations" (described below) in the theoretical portion of any subject they have qualified in.

As indicated above, the chance of getting a commission in peace time except through West Point is a remote one. When vacancies exist that cannot be filled from West Point, open competitive examinations are held, open to candidates with two years' service in the ranks and to persons in civil life.

As a rule Commissions to candidates from the ranks and from civil life are granted only in the Infantry and Cavalry, seldom in the Artillery, and never in the Engineers. Latterly the candidates from civil life have only been offered commissions in the Philippine Native Scouts.

This leads us to the system of allotting commissions in the various arms to Cadets who graduate at West Point.

A graduating class now usually consists of from 100 to 120 cadets. The Cadets occupying the first 10 places on the final passing-out list almost invariably elect to serve in the Engineers. Formerly the Cavalry, with its chances of service on the Indian frontier, was the next most popular branch; but latterly the Field Artillery has shared the next 30 or 40 places on the list, with a few Infantry commissions interspersed. The Coast Artillery is unpopular, owing to its remote and often unhealthy stations, and therefore usually claims the wooden spoon.

As the pay of all arms is practically identical, it is difficult to assign a cause for the preference shown for commissions in the Corps of Engineers. It may be attributed to the very important—but not any more highly paid—positions, open to officers of the Engineers, under Government in the branch of the Engineer Department which is responsible for the construction, maintenance and improvement of all the harbours and waterways of the United States and its foreign possessions.

All officers of the Engineers have now to do at least one tour of four years, as a Lieutenant or Captain, with the Engineer Battalions. They thus retain touch with the Army, and at the same time keep up to date with all the latest developments in Civil Engineering.

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WEST POINT ACADEMY.

Admission to West Point is obtained under a system of nomination, subject to passing a qualifying physical and mental examination. Two candidates are nominated annually by the Senators of each State and Territory of the Union, and a certain number of vacancies are allotted to the United States at large. The number of candidates thus admitted each year amounts to close on 150.

The course of instruction lasts 4 years. The age of the cadets at entrance is 17 to 21 years, and consequently the commissioned class varies in age from 21 to 25 years.

The standard required at the entrance examination is not a high one ; and this accounts for what would otherwise seem a waste of time in the large amount of study devoted during the first year to branches of purely general education.

The avowed object of the U.S. Military Academy is to give some 500 cadets a thorough education in all subjects directly or indirectly suitable to the corps of officers of a Regular Army ; to implant in them a spirit of discipline, soldierly feeling, and a sense of duty ; to work up their physique by drill, riding, athletics and gymnastics ; and, remembering that the cadets come from every class of the nation, to bring them up to a uniform standard of social habits, good manners and *savoir vivre*, in which points many are deficient on joining. The latter object is of course tactfully undertaken ; and is attained unobtrusively by the advice and example of the officers, by absence of all bad influences or surroundings, and by a surprising amount of feminine society. Constant dances are given, dancing is officially taught, and the cadets are always about the Academy with their young lady acquaintances, which is said to humanize them and keep them out of mischief. This is contrary to English habits, and leads to early marriages.

To turn to the actual instruction given, we find the field very wide even for a four years' residence. The mathematical course is a thorough one. The scientific course includes optics, acoustics, and heat, as well as chemistry and electricity, which are of more obvious use. The artillery course teaches internal and external ballistics. Geometrical drawing is carried further than at Woolwich. Surveying, theoretical and practical, is of course thoroughly taught. Instruction is given in military law, and even international law. Some popular astronomy is taught in an observatory, and there is an original and useful little course by the Librarian on the use of a library, on general reading, and on works of reference. English is a most necessary course, as many cadets have only a very elementary education. French and Spanish are taught by Army officers, the former only to read and not to speak ! All instructors are West Point graduates.

The classes are small. They consist of 8 to 12 cadets, each of whom is obliged by the recitation system to stand up and recite the

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lesson he has studied, giving written explanations, definitions, etc., on the blackboard. The pupil thus shows daily how far he is learning his work, and cannot depend on mere success in examination to obtain marks.

The above is in addition to purely military subjects, such as tactics, military history, army sanitation, fortification, riding, gymnastics, drill, musketry, and field work. The latter are taught during the ten weeks summer camp and not during the rest of the year, which is devoted to indoor work; but the daily sunset "dress parade," with the manual exercise and a march past, keeps up military bearing, correct turn-out, and stiff drill in great perfection.

There can be little doubt that the best result of the four years at West Point is the formation of character in the sense of enthusiasm for the army and the position of an officer in it, and of a high sense of duty, discipline and military virtue. The strictest veracity is learnt, and the integrity of a West Point officer has rarely been questioned among the 4,000 cadets who have entered the Army. Another excellent result is the homogeneity of the quality of the officers of the U.S. Army, and their unrivalled camaraderie, which continues till the end of their career. West Point is a religion deeply implanted, and common associations unite officers of all ages and of all arms of the service.

The training in drill, dress, habits of order in barrack rooms, and punctuality is very thorough. The cadet undergoes the private's training, only much more strictly; nothing is omitted. The curriculum includes guard duty, cleaning of rifles and belts, saluting cadet officers, grooming horses, driving guns, making beds, keeping rooms clean. No servants are allowed, except for scrubbing floors and cleaning boots.

There is, however, no attempt to teach more than the ground work of the duty of an officer. "The cadet is not supposed to be a thorough officer when he graduates, but to be fitted by his education to become one." His training as an officer takes place in the regiment or in the Service Schools.

An obvious drawback to West Point is the absence of ground for field training, which is only slightly attempted. There seems to be too much parade, stiff drill, marching past, and ceremonial. All this is a relic of the past century and is due to the great conservativism of the Academy.

The course of four years also seems too long for young men between 18 and 25 years old, subjected as they are to a high degree of restraint and confinement and hard work with their brains. The fact that a half, or even two-thirds, of those who enter are removed during their course shews the inexorable nature of the curriculum. But while severe on the individual, it accounts for the high standard of discipline and education attained.

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GARRISON SCHOOLS.

Garrison Schools are administered by the Commanders of the various Garrisons, who detail some of the senior officers as instructors. These teach by hearing "Recitations" and by practical work, but also give lectures and set problems for solution on paper or on a map.

"Recitations" play such an overshadowing part in military schools in the United States that they must be more particularly described. The student stands to attention, facing the instructor, at a blackboard, whereon he has written as a heading his own definition of that portion of the subject of the day which he has been ordered to "recite." He then recites or states as clearly and fluently as he can, and with as little prompting as may be from the instructor, what he knows of the subject. By this means it is seen whether he has learned his work, and care is taken that his pronunciation and language are correct, his ideas clear, and his expression lucid. In fact the student is taught to lecture to his instructor, while the rest of the class listen and learn. Two hours a day are devoted to recitations, and considerable time is needed for their preparation.

The theoretical course takes place between November and March, the practical during the other months. The whole course extends over three years, there being seventy-five school days in each year.

The course includes :—Drill and musketry, field service and tactics, administration, army regulations, discipline and law, field engineering, topography and sketching, international law, military hygiene, and hippology, in which latter mounted officers have a more extended education. Officers of Coast Artillery are, in addition, instructed in artillery material and explosives, ballistics, coast defence and permanent fortification ; while Engineer Officers undergo a highly technical course which it will be of interest to the reader to learn in some detail.

The course for Engineers consists of only two annual terms, each comprising 180 hours' instruction. Before the officer joins the school he must pass a theoretical examination in drill, tactics, hippology, hygiene, and military and international law. A practical course in these subjects is carried through in the first year, that in law taking the form of Court-Martial duty and problems in diplomatic situations. In the first year, too, instruction is given, as in the Infantry course, in administration, musketry, field service, topography and sketching ; while an advanced course of field fortification, surveying, and the construction of roads and railways is also laid down. The special drill regulations for Engineers, including pontooning, are also taught. Field engineering includes the design, and the superintendence of the construction of, rifle pits, shelter-trenches, loopholes and obstacles ; the use of mines and demolitions ; the making of revetments ; the employment of working parties ; tracing trenches and

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works with reference to the ground; and making fieldworks in model.

The second year is devoted to the civil or peace side of the profession. During this period are taught:—Particulars of water supply, sewage disposal, masonry, concrete, cement and mortar, roofs, bridges, heating, and ventilation. A thesis, or essay, has to be written on one of the subjects, selected by the instructor; and a practical course in military bridging also forms part of this year's training. In considering the instruction in building work it should be remarked that barrack construction in the United States is not carried out by the Engineer Corps, but by the Quartermaster-General's department, most of the Engineer Officers being employed on fortification and "river and harbour" works. As the Engineer Officers are, however, much in request for important public works, they are allowed to undergo the examination without following the courses.

It should be noted that in all Garrison school courses school duties take precedence of all others, but the officer students are employed when not at school on their military duties. No leave is granted to officers under instruction. A written examination is held in each subject, on a paper prepared in the War College, under the superintendence of a Board in each garrison; an officer who does not obtain 75 per cent. of the marks must attend the course again in the following year, when, if he again fails, he is reported to the Military Secretary and will probably be tried by Court-Martial for neglect of duty.

THE POSTGRADUATE COURSE.

After passing the Garrison School all officers undergo a further course in connection with each year's work in the school. In the first year an essay is written on a "suitable military subject" selected by the officer; the best of these essays is read to the assembled officers of the garrison, and any of marked merit are sent to the General Commanding and may be transmitted to the Chief of Staff for publication if desirable. During the second year's course the officers of the postgraduate class, as well as any field officers selected by the Commanding Officer, are required to solve a tactical problem prepared by the War College and also answer one paper in military and another in international law. During the third year they make a reconnaissance map of a route from 5 to 10 miles long. In this Postgraduate Course the student officer is allowed to discuss his work with his brother officers and consult any books; but he must draw his map and write his essay or the solution of his problem without assistance, and has to certify that this is the case. After passing this course the officer is not liable to any further school work or examinations, unless he joins one of the "Service Schools" to be now described.

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THE SERVICE SCHOOLS.

These consist of the following :—

The Cavalry and Infantry School at Fort Leavenworth, Kansas.
The School of Application for Cavalry and Field Artillery at Fort Riley, Kansas.
The Artillery School at Fort Monroe, Virginia (for Coast Artillery).
The Engineer School at Washington, D.C.
The School of Submarine Defence at Fort Totten, New York Harbour.
The Army Medical School at Washington, D.C.
The Signal School at Fort Leavenworth, Kansas.

The object of these Schools is defined as "to instruct selected officers in the duties of their arm in war and in the general military knowledge needed for the proper exercise of the higher grades of command."

Each School is administered by a Commandant, assisted by an Adjutant or Secretary, with a body of Instructors and Assistant Instructors. Each is located at some army post or garrison, with sufficient troops to enable the practical work to be carried out; but the Post Commander, although under the Commandant of the School, corresponds direct with the General Commanding so as to relieve the Commandant of the administrative duties of the Post. The Commandant and the Instructors form the "School Board," which arranges the programme of instruction, prescribes the examinations, and has the final decision as to the proficiency of the students. In all the Schools, except that at Fort Riley, where the work, being chiefly practical, goes on all the year round, the term is from September to July, with a short holiday at Christmas; the winter months are devoted to theoretical work indoors. The students are below the rank of Major, and the instructors above that of Lieutenant.

As in the Garrison Schools, instruction is usually limited to very small classes, of less than a dozen; and is mainly based on recitations, which ensure that the student has thoroughly prepared his lesson for the day. There are also lectures to the whole class together, and an individual course of reading is prescribed. Essays on subjects connected with the course, and theses on specified problems, are set from time to time. Great stress is laid on practical work, which forms wherever possible a large portion of all the courses. In field work with troops note is taken of the smartness and punctuality of the students, their ability to command and to give directions and instructions, their resourcefulness and powers of observation. The instructor satisfies himself of the proficiency of each student in the recitations and practical work in each subject, and reports to the Commandant any that are deficient; but no marking takes place except at the examinations, which are held in each subject on its completion as well as at the end of the course. At these

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examinations the Student must obtain 75 per cent. of the marks, failing which he must undergo re-examination, when, if he again fails to pass, he is reported to the War Department.

THE CAVALRY AND INFANTRY SCHOOL.

This school is the most important and also the largest, and is intimately connected with the Staff College, being carried on in the same building and under the same Commandant and Instructors, with, however, a separate body of Assistant Instructors. The students are selected by the Chief of Staff of the Army from two names sent in by each colonel of a Regiment; and great care is taken by the latter to select his most promising officers and not those he wishes to get rid of.

The present class includes 91 officers, divided into sections of 12 under an Assistant Instructor, so as to allow of personal attention being given in the recitations and practical work. These officers, mostly married, live in excellent roomy quarters near the school.

There is a large body of troops in the Post, comprising a unit of each arm, and including a battalion of engineers (nearly 280 officers and men) and batteries of field, siege and mountain artillery. Thus, with the students at the Staff College and the instructors, the station is a very large one, and the students are thrown with a number of brother officers of every rank and arm and experience; this cannot fail to be an education in itself, as officers who have been at our own Staff College will agree.

The course lasts one year, and embraces the following subjects, each group being superintended by one Instructor with his Assistants:—

(*a*). *Military Art.*—Tactics, organization, hippology, riding, field exercises with and without troops, strategy, signalling, telegraphy.

(*b*). *Engineering.*—Military topography, surveying, sketching, field fortification, engineering (*i.e.*, demolitions, roads, and camping grounds).

(*c*). *Law.*—Law in general, military and martial law, with practice in mock courts formed of the class.

(*d*). *Sanitation and Hygiene.*—The care of the health of the soldier, both in his own person and as regards his camps, quarters, drains, water supply, clothing, and the cooking of his food.

(*e*). *Spanish.*—This includes not only reading and writing the language but also a thorough conversational knowledge.

In the most important subject of *Military Art*, the practical work in the field is preceded by problems to be solved on paper, where the student marks his dispositions by a brush on ground glass laid over the map. This subject includes advanced and rear guards; patrolling and scouting; reports on positions and communications; outposts; marches; tactics of each arm in attack and defence, and of all arms combined. Similar problems are also solved in the field with imagi-

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nary troops, and later with troops. Great attention is paid to writing orders. The theses, or essays, include such subjects as "The best method of training non-commissioned officers," or the production of a set of problems for the instruction of a small Post. In these, as well as in the examinations, note is made of spelling and correct use of language and punctuation, as well as of clear and concise expression. The course of strategy is elementary, consisting of a dozen lectures, of an hour each, on various campaigns, followed by recitations and questions on them. Lectures on arms and ammunition are also given.

In the *Engineering* course the instruction is chiefly practical, and the fieldworks are carried out by the students unaided. It is interesting to note that this course is largely based on our text-books.

The course of *Law* is an extensive one, going far beyond military law and courts. It is considered that service abroad often results in officers having to become administrators and judges over the civil population, whereby they may at times be placed in positions of international delicacy.

THE SCHOOL OF APPLICATION FOR CAVALRY AND FIELD ARTILLERY.

This school includes one for Cavalry, one for Field Artillery, and one for Farriery. Its object is to give practical instruction to these two arms in their field duties, separately and in combined operations.

It is situated at Fort Riley, in wide rolling prairie country, where the War Department has some 20,000 acres un-enclosed, forming an excellent ground for mounted troops to work over. At the Post there are three strong squadrons of different regiments, forming the equivalent of one cavalry regiment, and five batteries of field artillery, two of which are being transformed into horse artillery. Some of these units are relieved yearly in order that the instruction received may benefit the whole army gradually; and the officers and non-commissioned officers of the units present, together with certain attached officers, form the School,—under a "director" for each arm. The course lasts for three years, and is as follows :—

CAVALRY SCHOOL.

In the first year elementary work and horse training are taken up, and in the next two years the following course, both theoretical and practical :—

Hippology or horsemastership, including :—knowledge of age, soundness, conformation, suitability for service; veterinary science; forage; shoeing; bits and bitting; saddles, and transport harness. Riding : in school, out of doors, and across country. Cavalry drill and tactics;

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campaigns with reference to cavalry. Reconnaissance and sketching; perspective sketching. Cavalry pioneer instruction; explosives; transportation; entraining and detraining.

THE FIELD ARTILLERY SCHOOL.

All Lieutenants of field batteries go through the following course of three years:—

First year: recitations in hippology, drill, and topography; organization and tactics (for First Lieutenants only). Second year: special studies for artillery; study of campaigns with special reference to artillery; topography. Third year: advanced course in field artillery, especially in practical work.

Experiments in field artillery material are also made at this School.

There is also a course for non-commissioned officers and selected privates of both cavalry and field artillery. This includes hippology, the drill of their own arm, reconnaissance and map reading; and for cavalry, in addition, drill and army regulations, elements of sketching, and field engineering, tactics, and shoeing.

An advanced course for artillery non-commissioned officers comprises telescopic sights, march tactics, demolitions, forage, care of *matériel*, road making, bridging, gunnery, artillery command, and target practice.

Both schools frequently unite for combined operations of the two arms.

THE ARTILLERY SCHOOL.

This school is at Fort Monroe, where there is a large armament of 12-inch and 10-inch guns on disappearing carriages, a battery of 12-inch howitzers,* and also 6-inch and smaller Q.F. guns, the whole manned by a garrison of 6 companies of Coast Artillery. There is an elaborate system of fire command, with lofty observing stations, as the site is low and does not allow of depression range finding. It is thus an excellent place for the study of Coast Artillery in practice, as well as a remarkably lively and pleasant station.

The course lasts one year, and corresponds somewhat to our "long course" at Shoeburyness. It has three branches, each under an Instructor with his Assistants;—

(*a*). Ballistics, theoretical and practical; coast fortification. (*b*). Electricity and its application to power; the use of submarine mines. (*c*). Artillery; explosives; coast defence.

Instruction is given by a course of private reading, by lectures, recitations, and the practical use of instruments and machines, as well

* Known as "mortars" in the United States.

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as by work with artillery *matériel.* Papers are also written by the students on specified points of the course.

In connection with this school is one for *Master Gunners*, where the course lasts from October to June, and includes :—

Algebra ; geometry ; trigonometry ; range tables ; coast fortification ; artillery methods and *matériel ;* mechanical drawing ; photo-printing.

THE ENGINEER SCHOOL.

The object of this school is not only to instruct the junior officers of Engineers in their profession, but also to make research into such branches of science as relate to the duties of the Corps and to disseminate the information thus obtained. Experiments are therefore made here in Engineer equipment, in field and permanent fortification, and in field engineering.

The school is located at the barracks of the battalion of Engineers at Washington, where there are some 400 men in 4 companies under a Major, who is Commandant of the School.

The course lasts for one year, except in the case of officers who have not passed the Garrison School for Engineers, for whom there is a preliminary course of one year in which the Garrison School course is undergone. There are four branches of instruction, namely :—

(*a*). *Military Engineering.*—Coast defences, their types, construction, attack, and defence ; submarine mines and torpedoes ; influence of sea power on land operations, including combined naval and military movements ; tactics and strategy.

(*b*). *Civil Engineering.*—Mechanical engineering ; hydrographic surveys ; triangulation ; field astronomy ; photography ; river and harbour engineering ; lighthouse construction ; contracts, specifications and estimates.

(*c*). *Electricity.*—Generation, transmission and application of electricity for lighting, heating and power ; military uses of electricity.

(*d*). *Ordnance and Armour.*—Guns, projectiles and explosives ; the use of fortification ; and some knowledge of vessels of war.

The vast field to be covered in one year cannot fail to be noted, as well as the exclusion of field engineering from the course, which is limited to coast defence and civil work. It should be understood that only some forty Engineer officers are doing duty with Engineer troops, of which there are 3 battalions of 4 companies of 104 men. The rest of the Corps, amounting to 146 officers, are employed exclusively on coast fortification, "river and harbour" works, and on lighthouse construction, besides one or two on civil work for the Federal Government at the Capital and one always acting as Controller of the President's Household.

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THE SCHOOL OF SUBMARINE DEFENCE.

Submarine mining has lately been transferred to the Coast Artillery. This school exists to instruct officers and men allotted to this duty in the use of the *matériel*, and to keep the service abreast of improvements in the electrical and steam plant of modern fortifications.

The course lasts one year, and comprises three branches :—

(*a*). Electricity, mines and mechanism.
(*b*). Chemistry and explosives.
(*c*). Special subjects approved by the War Department.

Instruction is given by a course of private reading, by lectures, and by the practical use of machines, instruments and apparatus. The students also write papers on specified subjects. At the end of the course the instructor reports on the proficiency of each student; and those who are not satisfactory are re-examined, and, if still deficient, reported to the War Department.

In connection with this school, there is a subsidiary one to qualify men for the position of Electrician Sergeant. Specially recommended men are examined at their station by an examination paper prepared at the School; those thus selected join the School in September for a six months' course, after which, if certified proficient, they are appointed Electrician Sergeants.

THE SIGNAL SCHOOL.

This school is being formed to prepare junior officers of the Signal Corps and certain attached officers of other arms for their duties, which comprise signalling, military telegraphy, ballooning and photography. Experiments will also be made in these matters in the school.

The students include 5 from the Signal Corps, 4 from the Artillery, and 12 graduates of the Cavalry and Infantry School.

The course will be of one year, and will include :—Signalling and telegraphy; ballooning; photography; topography; Spanish. Instruction and graduation will be regulated as in the other schools.

THE ARMY MEDICAL SCHOOL.

This establishment trains the Medical Officers of the army, and being of a highly technical nature will not be described in detail here. It is ably officered, lavishly equipped, and holds a high position in the profession. The army medical equipment is designed in it; but the training of the field units is carried out in two "companies of instruction," one with the school at Washington, the other at San Francisco.

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THE STAFF COLLEGE.

The above are the Special Service Schools for the different arms. We now come to the Staff College, which provides the higher military education for officers of all arms. It is situated at the same station (Fort Leavenworth) as the Cavalry and Infa ntry School, and is under the same Commandant and Instructors, but with separate Assistant Instructors.

The students are selected by the Chief of Staff from the highest graduates of the last class graduated from the Cavalry and Infantry School, 9 to 15 in number, to whom are added 3 to 5 Artillery and 2 Engineer Officers; all are below field rank, and with more than 5 years' service.

The present Commandant, Brigadier-General Bell, is considered one of the keenest and most efficient soldiers in the army, and is credited with the honour of being designated for the command of any expedition that the United States may send abroad. The Instructors are carefully selected; and are deeply interested in the work of training officers for the duties of the General Staff in war, as well as for the other object for which the College exists, namely to investigate the development of military science and to make recommendations for the improvement of the efficiency of the various arms of the service.

The course lasts two years, the terms beginning annually on the 15th of September and lasting till the following 30th of June, with a fortnight's holiday at Christmas. There are three departments of study, each under an Instructor with a staff of Assistants, namely :— Military Art—Engineering—Law. The subjects taught are :—

(*a*). *Military Art.*—Service of security and information. (This is taught by the preparation of problems, and by umpiring at and criticising the work of the Cavalry and Infantry School). Organization, mobilization, and concentration of forces at home and abroad. The movement and supply of armies. Tactics. Lectures on military history and strategy. Lectures on military geography, especially that of America and the East of Asia. Lectures on the duties of the General Staff. "Staff Rides," which are hardly what we should call staff rides but are merely exercises on the ground without troops in various staff duties, such as preparing orders for marches, manœuvres and battle, writing reports, and making maps of positions and route sketches. Lectures on navies and naval warfare, especially in combination with military operations, by a naval Officer. Campaign studies, by visits to battlefields.

A course of private reading is prescribed in these subjects, and recitations and practical lessons in instructing are also insisted on. The greatest attention is paid to the work in the field, during which note is made of the student's military bearing, punctuality, and even his personal smartness. He is taught to form up and inspect, and

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give his orders to, his troops in a soldierly manner; to pay attention to accurate estimates of time for marches and combined movements; and to write orders clearly and concisely.

(*b*). *Engineering.*—Surveying, levelling and sketching, especially including combined work covering large areas; processes for reproduction of maps; the supervision of the topographical work in the Cavalry and Infantry School. Lectures on permanent and provisional fortification; attack and defence of fortresses. Lectures on bridging and making dams. Superintendence of the field engineering in the Cavalry and Infantry School. Field astronomy; determination of meridian, latitude, longitude, and time.

(*c*). *Law.*—Constitutional law, martial law and military government, but not *military* law, which is taught in the lower schools. The idea is that Generals and staff officers may find themselves in positions where they have to administer civil law and government.

There are no examinations, as the students are all taken from those specially selected for the lower schools, and are sure to be of undoubted zeal and ability. The Academic Board makes a report on the qualifications of each student; the report is sent to the Military Secretary, and the graduate is distinguished in the Army List by the letters G.S.C. to his name.

The course of two years at Leavenworth is undoubtedly a very severe one to undergo, and it is said that the men there work 15 hours a day at times. It would seem that it covers too much ground for the time, for all the students can hardly have the indefatigable energy and concentration of the present Commandant. The College, however, has only recently been initiated, and it is possible that modifications may be made in its working.

THE WAR COLLEGE.

Above the Staff College comes the War College, the highest of the institutions of military education.

This consists essentially of the Third Division of the General Staff at Headquarters, to which is attached a small body of specially selected officers. The actual college is under construction at Washington, and will be a splendid building when completed.

The work to be done here may be described under two heads;—(1) the treatment in detail of actual problems which confront the Staff in preparing for War, and (2) the supervision of the military education of the Army.

Under the first head come:—The preparation of strategical problems for specially selected officers. Projects involving organization, mobilization, concentration, strategic plans and preliminary operations. (These no doubt will form the actual mobilization plans for various wars that may be possible). Analyses of foreign military

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systems, or parts of them. (These would be published from time to time, and would tend to the education, in addition to the army itself, of the Government, of Congress and of the public, with a view to facilitating the introduction by legislation of reforms deemed necessary by the Chief of Staff). The regulation and conduct of manœuvres.

The educational work consists of:—The preparation of tactical problems for officers at large Posts, and the examination of their solutions. The preparation of tactical problems for the post-graduate course in the Garrison Schools, and the examination of the essays written during that course. The direct supervision of the courses and instruction in the Post, Garrison and Service Schools and at the Staff College. The supervision and annual classification of the civil schools and colleges where army officers are detailed as professors of military science.

The above are undertaken by the permanent *personnel* of the War College, which consists of a General as President, a Colonel and a Lieut.-Colonel as Directors, a Secretary, and of all the officers of the Third Division of the General Staff.

The students are to be from time to time detailed by the Chief of Staff. There is no special time for the course, nor any examination or graduation.

The course of study comprises :—

(*a*). A critical study of an approved plan of operations, with a view to its confirmation or modification.

(*b*). The assumption of the original conditions on which an approved plan of operations was based, and the preparation of an independent plan, the two to be subsequently compared and discussed.

The above two items of work might, and probably would, be made use of to effect the periodical revision of the plans of campaign of the United States.

(*c*). A minute study of certain days' operations at an important period of the plan ; involving the preparation of every daily order directing the movements of the wagon trains, the tactical arrangement of the marches (assignment of roads to columns, arrangement of the columns on the roads, etc.), length of marches, tactical arrangement of camps, bivouacs, etc.

(*d*). In connection with the above the discussion of the special problems which face the technical troops, of the tactical use of the three arms, the supply of ammunition, the disposal of the wounded, etc.

(*e*). A War Game, in which an actual campaign (of the Civil War for instance) will be taken, but under present conditions of armament, equipment, organization and tactical methods.

(*f*). Informal lectures and discussions on current military events and developments.

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It is thus in the War College that the actual elaboration of the organization and plans for War will be carried out, by the General Staff there employed, assisted by the ablest officers of the army selected for this purpose. In working out these problems much will be learned, which will qualify the officers at the War College for the highest duties of the General Staff in the field and further for the responsibilities of the higher commands. It will thus answer to its name as in a real sense a school for War, and will form the crown of the structure of military education thus systematically built up.

But it is right to preferably regard the manœuvres as the war school for all officers, especially for the Staff Departments, the Staff, and the Commanders. As the Secretary of War says in his last annual Report, "They accustom officers of the higher grades to the command of troops under service conditions; they familiarize officers of all grades with the handling of their organizations in unexpected and varied situations, thus cultivating resourcefulness and military judgment; they give officers of the Staff Departments practical experience in the transportation and supply of troops"; and, most important of all, he might have added that they teach the Staff to compose orders, to distribute them with certainty and despatch, to arrange marches and combine movements, to be watchful, prompt and resourceful, and to relieve their chief of the detailed work so that he is free to form his strategical or tactical decisions.

This description of the system of military education laid down so comprehensively in the United States cannot fail to shew that the army is resolved to learn its work, and ready to go to school with that object. There is no doubt that the value and necessity of education has been taken to heart by all ranks; and that as a rule all officers, whether students or instructors, regard their school work as one of their highest duties. Were this not the case the wisest educational curriculum must fail in its purpose.

(Those who are interested in this subject are recommended to read:—an address on "The Present Military Educational System of the United States," delivered by Lieut.-Colonel A. C. Sharpe, U.S. Army, before the Colorado Commandery of the Military Order of the Loyal Legion of the United States, and printed in the April, 1905, number of *The United Service*; and also "The United States Army," a paper read at the Royal United Service Institution by Colonel Sir Howard Vincent, K.C.M.G., C.B., A.D.C., M.P., and published in its *Journal* of April, 1905.—EDR.).

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RIFLE RANGES.

By CAPT. A. B. CAREY, R.E.

ORDINARY CLASSIFICATION RANGES.

THIS type of range is dealt with somewhat fully in the official *Care and Construction of Rifle Ranges*, 1905, now in the printer's hands. It is therefore only necessary to refer briefly to one or two points regarding the danger area.

The size of the danger area as laid down has, on level ground and under normal conditions, usually proved sufficient; and instances of bullets escaping beyond the danger area have been generally due to ricochets and not to direct shots. The explanation of this is that bad or indifferent firers comparatively seldom miss over the target; more frequently their shots strike short and ricochet over the butts; and if by chance a stray direct shot does clear the butt, it seldom clears it by more than a few feet, and it consequently strikes the ground within 1,000 yards in rear of the targets and becomes a ricochet. The danger area does not therefore depend so much on the extreme range of the rifle as on the ranging power of the bullet after ricochet; and the majority of dangerous ricochets will rise from where the greater number of bad shots strike the ground, *i.e.*, just below the targets.

Experiments were carried out at Hythe to see what range and deviation might be expected from ricochets occurring on level ground off different natures of soil. The result of these experiments was to show that the nature of the soil had little to do with the extreme range of the ricochet, though it affected the lateral deviation considerably; and that our ideas of the maximum range of ricochets had to be considerably enlarged. Ricochets clearing 2,000 yards in one bound were not infrequent; while in one series of experiments the average range of the ricochets traced was over 1,500 yards. Very few fell short of 1,000 yards, and these would as a rule clear some hundreds of yards in their second flight. Angles of lateral deviation of 20° and over occurred; but off level homogeneous soil large angles of deviation are infrequent.

These results were checked by a few cases occurring in actual practice. On one range, which was very unfavourably situated, ricochets diverging laterally at 21° fell 1,600 yards behind the butt and 600 yards left of the axis of the range. In another case, on rising ground but smooth homogeneous soil, ricochets constantly cleared

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the 2,000 yards limit, although this was some 350 feet above the level of the targets.

The disadvantages of a rising line of sight are very fully dealt with in the new issue of *Care and Construction of Rifle Ranges*, and I need not therefore enlarge upon this subject here.

The following conclusions may be drawn as to the conditions which govern the size of danger area required on a favourable site :—

(*a*). Accidental shots are just as likely to be directed in any other direction than that of the targets ; but they occur very infrequently and may therefore be neglected.

(*b*). Comparatively few direct shots clear the butts ; and these as a rule strike the ground at a fair angle of descent within 1,000 yards, and lose a considerable proportion of their velocity on impact.

(*c*). Large numbers of ricochets occur off the marker's gallery and the ground immediately in front of the targets, and these ricochets chiefly govern the size of danger area required.

(*d*). As appreciable numbers of ricochets range 2,000 yards in one bound, and as these ricochets must follow a more curved trajectory than that of a direct shot ranging a similar distance, a hill of 200 feet in height cannot be considered an efficient substitute for a 2,000 yards depth of danger area.

Fig. 1 is interesting as shewing the danger area laid down for a classification range by the German Rifle Range Regulations for 1904. They allow for a depth of 2,500 mètres from the shortest range firing point, that is 2,350 mètres behind the butts ; and further state that an extra 500 mètres should be obtained when possible. As regards width they consider that ricochets may occur at 100 mètres in front of the firer, and diverge as much as 30° laterally. This 30° lateral deviation is presumably made up of 6° deviation allowed for a direct shot, and 24° extra for the ricochet (see also page 221).

PROTECTED RANGES.

The provision of a large danger area constitutes the chief expense incurred in obtaining a classification range. Many attempts have therefore been made to design systems of bullet-proof screens or walls so as to stop all chance of direct shots or ricochets escaping from the range either laterally or beyond the stop butt. Unfortunately none of these attempts has been entirely successful. I believe that the Belgians were the first to take up the question of protected ranges ; and they have now very fine ranges, magnificently fitted up, in many of their large towns. Other powers have followed the Belgian lead in experimenting with protected ranges, but it is now recognised by most continental powers that screened ranges do not

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provide immunity from ricochets unless they are practically tunnelled. As however different countries have followed different types of design, I propose to give a brief description of each of the main types.

BELGIUM.

The Belgians (*Fig. 2*) site their protected ranges in the outskirts of large towns, directing the line of fire towards the open country. Firing at various distances from 200 to 600 mètres is usually provided for. A considerable number of targets are erected, perhaps 30 or more.

The system of screening consists of:—first, an iron-plated embrasure, in which the muzzle of the rifle is placed when firing; second, a transverse loopholed wall some 15 or 20 mètres in front of the firer, with a loophole just large enough to allow the firer to see the targets and to allow for the rise of the trajectory of a high shot fired by a tall man directed at the top of the targets. To avoid the very high stop butt that would be required to catch a bullet fired by a short man in such a way as to pass through the upper part of this loophole, one or more overhead screens are usually provided further down the range at 40 to 80 mètres from the firer.

In *Fig. 2*, A is the building in which firing takes place, B the roof of the embrasure; the function of this roof is to catch direct shots which might clear screen C. Screens C, D, and E are also utilised to catch direct shots and consequently to reduce the height of stop butt required. In calculating the height of stop butt the Belgians usually allow for the curve of trajectory of a direct shot which just passes under screen D. The supports of screens D and E are not always out of the line of direct fire and consequently are productive of ricochets. This arrangement of screening is not a good one, the main reason being that owing to the curve of trajectory the bottom edges of screens D and E come very near the path of well-aimed shots directed at the long range targets; consequently numerous shots strike these lower edges and rebound again from the ground. Screen E is also usually of such a height as to catch those ricochets off the bank under C which just escape under screen D, but the possibility of finely grazing shots from the same source escaping under E and over the stop butt is not contemplated.

There are several rows of targets at different distances from the one row of firing points, and a stop butt is provided only behind the last row. The firer is therefore able to see most of the ground from 200 mètres to the longest range; and consequently the ground can be struck almost anywhere by a badly aimed shot, and ricochets may occur which will escape from the range. An attempt is made to minimise the chance of ricochets by keeping the ground soft by frequent ploughing or by laying down tan, but these remedies are not entirely successful.

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As regards ricochets off the face of the loophole, these are mostly caught by small splinter proofs close behind the loophole, but no provision is made for catching bullets which graze the edges of these cheeks. Such grazing shots escape in a variety of ways, either by clearing the stop butt direct from the bottom edge of the loophole, or by ricochetting from the ground and then out after having grazed the top or a side edge of the iron cheeks.

Sometimes ricochets off the edges of the controlling loophole will strike the edge of a screen or of one of the uprights or stays of an overhead screen further down the range, and be deflected out by that.

In cases where there are several rows of targets, bullets escape off the crest of the markers' galleries, easily clearing the stop butt in spite of the careful raking over of the soft tan. It is almost impossible to keep the tan free from bullets, and bullets lying there are sometimes struck by another bullet and thus cause a bad ricochet. Besides this, tan, though it undoubtedly stops a great many shots from becoming ricochets, does not stop all, and sometimes bullets will leave tan with a very considerable deflection.

In a lateral sense these ranges leave much to be desired, and double edgers and curlers are not considered probable. But a careful examination of the supports of the ricochet screens showed that double edgers undoubtedly occur.

There are many complaints in Belgium from the occupiers of land in rear of these ranges; in 1903 I was informed that one range had had to be closed on this account and that another range was going to be moved further out into the country. There can be little doubt that the life of ranges of this description is a short one, and terminates directly building operations begin in rear of the butts.

FRANCE.

The French experimented at some length with the Belgian type of protected range, several of which were built in the vicinity of large towns. They were unable however to obtain a sufficient degree of safety until they eventually closed them in entirely.

Their type range is a four-section 200-mètre range on Belgian lines, but with a larger opening to the controlling loophole. To the system of screening originally adapted from the Belgians, but considerably modified as the result of experiments, longitudinal walls of concrete have been added. These side walls extend from firing points to butts on either flank of the range; and support a nearly flat roof, made of concrete where it is most liable to be struck by ricochets, the rest being of a double thickness of stout corrugated galvanised iron sheets.

Transverse ricochet banks of from two to three feet in height are provided along the floor of the range. Narrow openings, protected

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by wings, are left in the side walls to admit some air and light to the interior. The arrangements as regards firing platforms and window openings at the firing point are much the same as in Belgium, except that a small open shed takes the place of the large buildings of the latter country.

ITALY.

Experimental work was carried on in Italy between 1897—1900 with a view to obtaining a satisfactory protected range; and the conclusion arrived at as the result of these experiments appears to be that the most suitable type of range was one limited to about 200 mètres in length, provided with a large stop butt and side wings and with a special apparatus for controlling the movement of the firer's rifle. This apparatus consists of a telescopic stand, about 6 feet in height, having a small brass ring which can be adjusted to suit the height of the firer's rifle. The firer inserts the muzzle of his rifle in this ring, which is of such a size that, so long as the firer occupies the correct firing position, the muzzle of his rifle cannot deviate laterally or vertically enough for him to miss the stop butt.

A somewhat similar apparatus has been tried in France and Germany, but does not appear to have been accepted in either country as suitable for general use. As the value of the ring depends entirely on the immobility of the butt end of the rifle, it is somewhat doubtful whether it would be of much practical value with recruits who flinched or otherwise allowed their bodies to move while pressing the trigger. On the other hand the ring would certainly reduce the proportion of dangerous shots arising from jerky trigger pulling, which causes the muzzle of the rifle to be deflected either in a lateral or downward direction.

GERMANY.

There are two types of semi-protected range in Germany. Type A is that employed where ranges are adjoining one another and lateral space is restricted. It consists of a system of earth banks, some 2 mètres in height, so arranged as to defilade each range from that next to it from danger of direct shots; transverse ricochet banks are also provided as a rule on the floor of the range.

Type B (*Fig.* 3) is a design with screens, but very different to the A pattern, and provides only protection against accidental direct shots escaping from the range.

The firing positions are shewn on the plan by small arrowheads; in the sectional elevation two short horizontal lines give the highest and lowest positions of the rifle for each firing point. The plan shews the method in which converging lines of fire are used, so that one target serves all three firing positions and yet the screens for the short distances do not interfere with the line of fire from the long

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range firing point. The shaded portions in the plan are the traverses which defilade the ground floor of the range from direct shots.

In Germany ranges are often constructed in a forest, each section having its own firing way cut through the wood and being separated from the next by a narrow belt of trees. This arrangement requires a great deal more lateral space than would be required for the same number of sections arranged according to the English custom; but the Germans claim as an advantage that the firers are not incommoded by the noise of the firing on the sections to their right or left, and also that each section is independent, *i.e.*, that firing may be carried out at 150 mètres on one target while the man on the next section is perhaps firing at 300 mètres.

Each section has positions and screens provided for firing as a rule at three consecutive distances, *e.g.*, 150, 200 and 300 mètres, or 400, 500 and 600 mètres. These screens are of shingle between boards backed with steel plates. They are about 2 mètres square, and are built on stout posts so that the bottom edge of the screen is some 1½ mètres above the ground level. An opening about 1′·6″ square is cut in the centre of the lower part of the screen, through which the firer can see the target. The screens therefore afford no protection against low shots striking the ground and ricochetting out of the range; but the German regulations lay down that no man will hit the ground within 100 mètres of the muzzle of his rifle, and to defilade the rest of the floor of the range they provide traverses topped with sand boxes. These sand boxes, if well looked after, form a fairly efficient preventive against ricochets; but they are not an absolute safeguard, as any bullet striking a sand box within about 6 inches of the top edge has a chance of getting out, a chance which improves as the distance from the top edge decreases.

At the firing point platforms are provided so that the rifle shall always be at approximately the same height from the ground whether the firing is being carried on in the standing, kneeling or lying position. The openings in the screens are large enough to allow for differences due to varying heights of individuals.

The size of the screens varies with the distance they are apart, the second screen being large enough to catch any wide or high direct shots which pass through the opening of the first screen. Similarly the third screen is large enough to catch bad shots passing through the opening in the second screen, and the stop butt is large enough to catch bad shots passing through the opening in the third screen.

No provision is made against ricochets off the edges of these openings; the degree of protection afforded by these ranges is therefore strictly limited.

The main lesson to be learnt from these ranges is the extraordinarily good shooting of the men who use them; there were extremely few bullet marks on the screens of the ranges I visited, although these

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had been in use for some years and the screens had had no repairs done to them. The screening of protected ranges in other countries usually shews a large number of bullet marks within a year of being taken into use.

The conclusions of the Germans with regard to the value of protected ranges are given in the following extracts from their Rifle Range Regulations of 7th October, 1904 :—

"*Classification Ranges.*—Screened ranges are costly and make instruction in shooting more difficult. Their employment therefore should be limited to districts where roads, railways, villages or canals, etc., might be made dangerous from direct shots, or where no other means of protection would provide sufficient safety. Screens can in no wise stop danger caused by *ricochets* diverging either to the side or beyond the targets ; therefore, whenever complaints are raised about danger, and before any plan is drawn up for erecting screens in consequence of these complaints, the most careful enquiry must be made to see whether the danger was caused by direct shots or by ricochets."

"*Field Practice Ranges.*—If the ground is 4,000 mètres in depth, then no means need be taken for protection against ricochets. Since on Field Practice ranges it is impossible to protect villages, railways, etc., from direct shots, therefore 4,000 mètres depth of danger area is necessary."

ENGLAND.

The first protected range of importance to be built in this country was that at Wormwood Scrubbs, on Belgian lines but considerably improved. This is a range of 200 yards. It has firing points at different levels, so that the firer's rifle is always at approximately the same height ; a controlling loophole with iron cheeks ; a splinter screen and also an overhead screen further down the range, and two ricochet banks to stop grazing shots off the top edges of the loophole ; also a very high brick wall stop butt built close up to the targets, and doubtless the range owed its fairly long life to this as much as to the screening.

The principal improvements in this range over the Belgian type are :—

(1). The loophole is so sited that the firer cannot strike the ground unless he raises his rifle to such an extent that he loses sight of a considerable portion of the target.

(2). The overhead screen is so cut away that its bottom edge cannot be hit by direct shots, and is therefore not productive of that type of double ricochet which rebounds from the ground and so out of the range.

(3). Ricochets off the marker's gallery are prevented by the fact that the range is for one distance only, and the stop butt is very high and rises almost vertically behind the targets.

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(4). Curling shots (in a vertical sense) are largely, but not entirely, prevented by the large excess of height in stop butt and screens over that which would be required to catch ricochets rising with ordinary trajectories from the bottom edge of the controlling loophole.

In a lateral sense the range is not nearly so perfect in design and there are many opportunities for bullets to escape the range, especially if fired from firing points close to the flanks of the range. I do not however think that these defects were the most serious cause of complaint. The chief defect lay in the very low controlling loophole, giving rise to numerous shots grazing the top edge and then striking the ground further down the range; these would rebound at a very steep angle and clear any stop butt.

From 1902—1904 experiments were carried on with a view to determining what degree of safety could be obtained on a protected range, and eventually a 3-section range, 300 yards in length, was built at Hythe in a safe position where experiments could be carried out without danger to the public. The principle on which the design was got out was on Belgian lines; but with the provisos that no direct shot could possibly strike any object beyond the controlling loophole except the marker's gallery, targets or stop butt; and that no grazing ricochet travelling from an edge of the controlling loophole in a curve approximating to that of a direct shot could escape the range, unless :—

(1). It grazed a second edge further down the range, or

(2). Was considerably deflected in its flight by extra resistance of the air caused through unsteadiness of the bullet after grazing.

Some experiments with ricochets, made prior to the drawing up of this design, had led to a false conclusion that bullets grazing an iron edge were never deflected at a less angle than 1 in 40, and this minimum angle of deflection had been confirmed by independent experiments made away from Hythe. The design was therefore so drawn up that the edges of the opening in the last ricochet screen were within the deviation of 1 in 40 from the edges of the controlling loophole although outside the widest lines of direct fire. It was therefore hoped that the possibility of double edgers had been avoided. When the expert rifle shots at Hythe were able to set to work methodically to prove or disprove the possibility of curling shots, double edgers and the like, this minimum deflection theory fell to the ground; and after a time they were able to obtain very finely grazing shots at the rate of about 3 per cent. of rounds fired, whereas ordinary grazing shots occurred at a rate of about 15 per cent. Many of these finely grazing shots travelled steadily down the range and struck the gallery or stop butt, and some even went through the target, but the fact that they occurred showed that the possibility of a double edger off the last screen was not improbable. The first graze on the controlling loophole was frequently most difficult to trace,

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and a most careful examination of the edges of the loophole had to be made in order to determine whether the bullet had touched or not.

The most frequent causes of bullets escaping were, however, double edgers off the openings in the nearer ricochet screens and curling shots. These latter appeared to strike in the most extraordinary places, where it seemed impossible for a bullet to reach without going through a screen containing a 6-inch thickness of shingle. After a time however the mystery was traced out by putting up thin paper screens. A bullet, after finely grazing the controlling loophole edge, was only slightly, if at all, deflected in its flight; it was however rendered unsteady in flight, its nose and base wobbling like a gyroscope that has received a blow while spinning. The bullet however gradually steadied down again (sometimes in 20 yards, sometimes in 60 yards, and at times taking more than that); but when steady its nose was no longer pointing in the direction of its flight, but more or less at an angle to it, either up, down, to one side or diagonally. The consequence was that the air resistance came into play on the side of the bullet, and apparently brought two forces into play, one tending to make the bullet follow the direction of its nose and the other tending to make its nose turn back into the direction of its flight. As a result the bullet appeared to compromise, and its final direction, as shewn by the last screen which it struck, was usually at a somewhat less angle of deviation than the angle through which its nose was deflected when it was first steadying down. The largest angle of deflection satisfactorily measured was 1 in 17 between the chords of the trajectory as taken at 3 points, viz., 1st where the bullet grazed the controlling loophole, 2nd a thin paper screen, 3rd a thick paper screen 60 yards from the loophole. Larger angles of deflection undoubtedly occurred, but the bullets cleared the last screen and it was therefore impossible to take measurements.

In this connection it is interesting to note that the penetration of a ricochet, though comparatively small while the bullet is wobbling, increases again as it steadies down in flight; and it would seem very possible that the explosive effect sometimes noticed with the service bullet at very short ranges is due to unsteadiness, which is highly accentuated on meeting with resistance.

For these experiments firing was carried out by expert shots from the lying position with a sandbag rest, and the edges of the loophole were deliberately aimed at. The proportion of hits obtained on the actual edge of the loophole varied from 20 to 40 per cent. of rounds fired, of which number about one-third to one-half would be finely grazing shots. The number of bullets escaping from the range was as a rule about 1 per 200 rounds fired, or 1 per 35 edge hits obtained. The proportion of edge hits probable on a range of this description used by average troops, as calculated from an actual diagram fired by a half company of a line battalion, is about ·5 per cent. of rounds

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fired; from this it would appear that about 1 bullet would escape from the range for every 7,000 rounds fired on it in ordinary use.

In the sectional diagram of the Hythe 300 yards protected range (*Fig.* 4) the vertical lines 1, 2, 3, 4, 5, shew the bullet-proof screens and openings in them. No. 3 is the main screen, containing the controlling loophole; its function is to prevent any but well-aimed direct shots travelling down the range. No. 1 is a subsidiary screen to prevent badly-aimed shots missing No. 3. No. 2 catches the ricochets off the edges of No. 1 loophole. No. 4 catches the more widely diverging ricochets off the edges of the controlling loophole in No. 3 screen, and No. 5 catches the more finely grazing ricochets from the same source.

The chain-dotted lines represent direct shots, one fired from the lowest possible firing position with the highest possible elevation, the other fired from the highest possible position with the lowest elevation consistent with the bullet going through the controlling loophole. It will be noted that the edges of the openings in the 4th and 5th screens are clear of these direct shots.

The lines drawn in groups of 3 dashes each represent the most diverging single edgers that can escape through the opening in the 5th screen; it is these single edgers which determine the size of the butt.

There are thus two main objects in this design:—Firstly the arrest of badly aimed direct shots (by screens 1 and 3); secondly the arrest of ricochets arising from bullets which have grazed the edge of one of the openings in those two screens (by screens 2, 4 and 5). It is evident that a third system of screening can be devised, which would give protection against double edgers and incidentally a considerable degree of protection against curlers. A design was drawn up on these lines, but was abandoned on account of the expense involved and the fact that, even with the addition of this third system of screens, absolute safety would not be obtained.

Many forms of controlling loopholes were tried with a view to minimising the number of dangerous ricochets; but no other form gave such good results as those obtained by the Belgian pattern of steel plate, sloping at about 25° to the line of fire and with the edge carefully rounded over so as not to be rapidly destroyed by bullets grazing it.

As regards the edges of the openings in the ricochet screens, these were at first of wood. But double edgers were so frequent, owing to the fact that the whole thickness of the wood facing was productive of ricochets, that these edges were lined with angle steel so fixed that one face was nearly at right angles to the path of ricochets from the controlling loophole, the other face being defiladed from them. By this means the amount of edge productive of ricochets was reduced from about 2½ inches to ·3 of an inch, and a considerable reduction in the number of double edgers resulted.

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THE ENGINEERS OF THE SPANISH ARMY.

DUTIES.

THE Engineers of the Spanish army form one corps, the Cuerpo de Ingenieros, and their duties are very similar to those of the British Royal Engineers.

In war time they execute the works of fortification that are required, and supply the means of communication necessary to the army (viz., roads, bridges, railways, telegraphs, visual signalling, and pigeon post). They are also responsible for ballooning, for field electric lighting, and for the destruction of communications.

In peace time they are charged with the construction and maintenance of all military buildings, including fortifications and barracks. Submarine Mining is in the hands of the Navy.

ORGANIZATION.

The Engineers, in common with the rest of the Spanish army, have just been reorganized, and from the 1st January, 1905, their organization is as follows :—

Troops Quartered in the Peninsula :—

7 Mixed regiments of Sappers and Telegraphists.
1 Company of Telegraphists for the Madrid telegraph system.
1 Regiment of Pontoniers.
1 Railway battalion.
1 Balloon and Field Electric Lighting company.
1 Topographical brigade.
1 Company of workmen.
7 Reserve depôts.

Outside the Peninsula :—

*Balearic Islands.**

2 Companies of Sappers	}	One of each at Palma and one of each at Mahon.
2 „ „ Telegraphists		

* The Balearic Islands are divided into two groups, one consisting of Mallorca, Ibiza, Formentera and Cabrera, the other of Menorca. Each group has a Commanding Engineer, who has command of the engineer troops in his district and is in charge of the technical work of the corps.

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*Canaries.**

2 Companies of Sappers	}	One of each at Santa Cruz de Tenerife and one of each at Las Palmas.
2 „ „ Telegraphists	}	

Ceuta and Melilla.

1 Company of Sappers	Ceuta.
1 „ „	Melilla.

The Regiment of Pontoniers, Railway Battalion, Balloon Company, Topographical Brigade, and Company of Workmen do not form a part of any particular army corps; but they are attached to the corps in whose district they are quartered, and are, for instructional purposes, under the orders of the Corps Commanding Engineer.

Mixed Regiments.

Each mixed regiment consists of 2 depôt and 6 active companies, of which 5 are sapper companies and the 6th a telegraph company.

The sapper companies preserve the same organization as under the old system.

The telegraph company consists of three distinct sections, two of which are electrical, viz., a field telegraph section, a mountain telegraph section, and a visual signalling section consisting of the men and material required for 8 stations. Each brigade of Cazadores (rifles) has a mountain telegraph section attached to it.

The depôt companies have duties analagous to those of the third battalions of line regiments, *i.e.*, they deal with the active reserve.

These 7 mixed regiments have been formed from the 4 previously existing regiments of Sappers and Miners and from the telegraph units which they replace, utilizing their men, animals, clothing and material. Each of the new mixed regiments numbered 1 to 4 is formed from the corresponding regiment of the old organization and is quartered in the same place (viz., No. 1 at Logroño, No. 2 at Madrid, No. 3 at Sevilla, No. 4 at Barcelona), and they are considered as in every respect the successors of those regiments. The 3 remaining regiments, numbered 5, 6 and 7, are quartered respectively at San Sebastian, Valladolid and Valencia, and are being organized at those places. Detachments from these regiments are sent out from the headquarter station to other places in the command; thus the 3rd Regiment at Seville furnishes the detachment of engineers in the Campo de Gibraltar.

Transport.—The animals necessary for the pack sections of 2 of the sapper companies of each mixed regiment, the field section of the

* The Canaries are divided into two military governments, the western group consisting of Tenerife, La Palma, Gomera, and Hierro, the eastern of Gran Canaria, Lanzarote, and Fuerteventura. Each government has a Commanding Engineer.

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telegraph companies of the 2nd and 4th Regiments, and the mountain section of the telegraph companies of all seven regiments appear in this year's estimates. The rest will be provided later.

Attachment to Corps.—Each regiment is attached to the Army Corps of the district in which it is quartered, and the Corps Commanding Engineer is responsible for its theoretical and practical instruction.

Formation of Second Battalions on Mobilization.—On mobilization each of these mixed regiments will form a second battalion out of the reserve companies and the 5th Sapper Company, the telegraph company being either divided between the battalions or allotted to that one which most requires it. The Major takes command of the second battalion.

Parks and Matériel.—Under the old organization the regiments of Sappers and Miners had on charge in their barracks *matériel* corresponding to that of one company on a war footing, the remainder being kept in the Engineer parks, with the exception of that of the 2nd Regiment, which was kept in the arsenal at Guadalajara. Engineer parks and storehouses exist in almost all garrison towns and are supplied from the central stores at Guadalajara. There were fortress and field parks at Barcelona, Cadiz, Madrid, Cartagena, Zaragoza, Ferrol, Valladolid, Vitoria, Burgos, Granada, Ceuta, Pamplona, as well as the Canaries and Balearic Islands. The siege and reserve parks of the Sappers and Miners and the tools of the parks in course of formation are on the charge of the Talleres del Materiel (workshops) at Guadalajara.

Madrid Telegraph Company.

For the telegraph service of the Madrid system, and for duty at the General School of Military Telegraphy, there is one company, which is organized from the previously existing Telegraph Regiment.

Regiment of Pontoniers.

The Regiment of Pontoniers is quartered in Zaragoza. Its establishment is :—

	Colonel.	Lieut.-Colonel.	Majors.	Captains.	1st Lieutenants.	Medical Officers.	Veterinary Officers.		Riding Master.	Men.	Animals.		Wagons.
							2nd Class.	3rd Class.	2nd Class.		Riding.	Draught.	
Peace.....	1	1	3	7	13	1	1	1	1	400	60	115	72
War	1	1	2	11	34	2	4	4	1	1723	227	962	153

The regiment is organized in 4 companies in peace time and 8 in war time, each commanded by a captain with 3 first lieutenants and 80 men in peace and 119 in war, including trumpeters, farriers,

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smiths, pontoniers, and 1st and 2nd class tradesmen. Each company has the *matériel* necessary for the construction of 75 mètres of bridge. In 1897 the bridging material was changed from the Birago type to the Danish type, being constructed in the workshops at Guadalajara. The bridging material not in use by the regiment is stored at Guadalajara.

Railway Battalion.

The Railway battalion is quartered in Madrid, and works, for instructional purposes, the line between Madrid and Villaviciosa de Odon.

Its establishment is :—

	Lieut.-Colonel.	Majors.	Captains.	1st Lieutenants.	Medical Officer.	Veterinary Officer.	Men.	Animals.		Wagons.
								Riding.	Draught.	
Peace.....	1	2	7	13	1	—	397	3	4	32
War	1	2	7	18	1	1	1057	31	194	49

It is organized in 4 companies, each commanded by a captain with 3 first lieutenants.

Cyclist Section.—There is a cyclist section attached to the railway battalion. Its organization is of a permanent character, and it is charged with the service of communication in the field and at manœuvres, being then attached to Headquarters.

Railway Park.—The railway park, which was formerly a separate unit, is now attached to the battalion.

Balloon and Electric Light Company.

The Balloon and Field Electric Lighting Company is quartered at Guadalajara. Its war establishment is :—

Major.	Captains.	1st Lieuts.	Men.	Animals.		Carts.	Wagons.
				Riding.	Draught.		
1	2	4	100	10	30	1	3

The Balloon Company is in peace time commanded by the Commandant of the Balloon Park, who is also in charge of the central carrier pigeon loft at Guadalajara (see last para. at end) and of the Military Photographic Section. Ballooning was first recognized in the Spanish army by Royal Decree of 15. 12. 84. The Balloon Park and Company are now directly under the Minister of War, and are administered by the General Staff, which is entrusted with the inspection of military communications in general.

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The Balloon Park and Company has the following staff in peace time :—

C.O. of park and company	1 lieut.-colonel.
Major and Superintendent of instruction...	1 major.
For technical studies of park	1 captain.
Captain of the company, also in charge of the pigeon loft	1 captain.
Treasurer and in charge of the technical material	1 captain.
Duties of the park and company	4 1st lieutenants.
Quartermaster	1
Storekeeper...	1
Paymaster of the park	1
„ „ company	1

Both spherical and sausage-shape balloons are in use.

Topographical Brigade.

The duties of the Topographical Brigade are the preparation of plans of fortifications, districts, places and frontiers, and in general the execution of all classes of topographical, geodetic and lithographic work. In the field it will be attached to the H.Q. staff of the army, under the Commanding Engineer. Its Headquarters are at present at Pontevedra.

Its establishment is :—

	Lieut.-Col.	Major.	Captains.	1st Lieuts.	Men.	Animals.		Wagons.
						Riding.	Draught.	
Peace	1	1	2	2	80	2	—	—
War	1	1	2	6	224	10	8	2

It is organized in two companies, and is under the orders of the General Staff of the Army.

Company of Workmen.

The Company of Workmen is stationed at Guadalajara for duty in the workshops there. Its establishment is 1 captain, 1 1st lieutenant, 110 men.

Reserves.

The active reserve of the Engineer units is under the orders of the O.C.s of the corresponding regular units ; in the mixed regiments the depôt companies deal with the active reservists.

In each army corps district there is an Engineer reserve depôt, which deals with the members of the second reserve who, having served in various units of the corps, happen to be residing in the district.

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Engineer Services.

In addition to the military units already mentioned there is an organization for carrying out the Engineer Services. Commanding Engineers, with a staff of Division Officers and subordinates, are appointed to army corps and districts, and carry out the Engineer Services in a similar manner to that which obtains in the British army. The Commanding Engineer also exercises command over the Engineer troops in his district. These districts are known as Comandancias (Generales) de Ingenieros. The Comandancia General of each Army Corps district is in charge of an Engineer brigadier-general or colonel.

The Engineer Services are carried out to a certain extent by the men of the regiments of Sappers, and to a much greater extent by civilian workmen. When the latter are employed they are in charge of the Division Officers of the garrisons in which the works are being executed. Employed on Engineer Services under officers of the Corps is the "Personal del Material de Ingenieros," which consists of the quartermasters (oficiales celadores de fortification) who deal with accounts and the details of fortification and barrack services, foremen of works, clerks and draughtsmen, workshop foremen, and (in Africa) clerks of works. Of these persons only the quartermasters hold military rank (varying from captain to sergeant, according to class). The remainder only hold relative military rank for a few specific purposes.

SUBORDINATE ESTABLISHMENTS.

In order to assist it in carrying out its various duties the Corps of Engineers has a number of subordinate establishments, many of them at Guadalajara, the Chatham of the Corps. Up to 1901 they were grouped together there as the "Central Establishment," but have since become independent units.

They consist of the following :—

Central Institute of Electricity, etc.

(1). A Central Institute of Electricity and Communications, located at Madrid and attached to the Telegraph Company of the Madrid system. This is charged with :—

(*a*). The study of the water supply of the waterfalls of the river Tagus, granted to the War Department for military purposes.

(*b*). The General School of Telegraphy. In order to ensure uniformity all the telegraphists and N.C.O.'s of the telegraph units are passed through this school.

(*c*). Experiments and studies necessary for the Communications service, the workshops and central telegraph park, and the work connected with the completion of the Spanish visual signalling system.

This Centre, together with the balloon park and company, the railway battalion and all the telegraph units, is subject, as far as the

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special service of communications is concerned, to the Central General Staff.

(2). The Laboratorio de Ingenieros. Laboratory.

The great importance which has been attached for some years to the technical study of building materials caused a Royal Order to be issued on 14. 6. 85 for the formation of a laboratory, under the orders of the "Junta Especial del Cuerpo de Ingenieros" (Engineer Committee), in which the necessary studies could be made.

After numerous changes it was reorganized by R.O. of *22.* 4. 97 and now deals with the following subjects:—Determination of the specific constants and physical, chemical, and mechanical properties of building materials. Collection of technical and economic data relative to building materials. Distribution of information as required regarding the properties and use of all kinds of machines, tools, and materials used in the engineer works and services. Purchase of such tools as cannot be made in the Central Corps Workshops. Experiments which may be required for testing the quality of materials used on the works. Construction of detonators and fuzes required by the Sappers and Miners, also of rockets and fog signals for the railways. Study of explosives from the point of view of their application and employment by the Engineers. In conjunction, if possible, with the Central School of Gunnery, the study of the effect of explosives on defence works.

It has a colonel as director, with a lieut.-colonel as executive officer, *2* captains and a quartermaster, and is located in Madrid.

(3). The Arsenal (Maestranza) and Workshops (Talleres del Material) situated at Guadalajara, with a colonel as director, 1 major as executive officer, 1 medical officer, 1 superintendent, 1 paymaster, 3 storekeepers and the above-mentioned company of workmen. This establishment consists of the workshops, where the tradesmen of the corps are trained, and where as much work as possible is done in connection with the construction, repair, and maintenance of the bridge trains, and of the war *matériel* and tools of the fortress and field parks established in the more important fortresses and garrisons. There are numerous siege, fortress, bridging, field, pack-train and other parks, and a large depôt of *matériel* in connection with this establishment. Arsenal and Workshops.

(4). The Record Office at Guadalajara. Record Office.

(5). The Engineer Museum and Library at Madrid, with a colonel as director, 1 captain, *2* quartermasters, 1 superintendent and 1 paymaster. Museum and Library.

OFFICERS.

Engineer Academy.—The Engineer Academy is situated at Guadalajara and corresponds to both the R.M.A., Woolwich, and the S.M.E., Chatham. It is under a colonel as director, with a lieut.-

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colonel as second in command, 1 major as executive officer, 15 majors and captains as professors, and two 1st lieutenants as assistants; also 1 medical officer, 1 veterinary professor, and 1 quartermaster.

Admission into the Corps.—Entry into the commissioned ranks of the Corps of Engineers is made from this Academy, which is the centre of instruction for the officers of this arm of the service. Candidates for admission must comply with the following conditions:—(1). Be Spanish subjects. (2). Be within certain age limits (17 minimum and 28 maximum, the latter only in the case of men who have served at least 2 years in the ranks). (3). Be physically fit and up to standard of height and measurement. (4). Be otherwise fit for the public service. (5). Have never been expelled from a place of public instruction. The candidates petition the Director of the Academy, transmitting various certificates as to birth, etc.; they do this direct if civilians, and through their C.O.s if serving. There is an entrance examination in the spring of each year, candidates being examined in Spanish grammar, geography, history, elementary physics, French translation, freehand drawing (copying an engraving of a head), arithmetic and algebra, geometry and trigonometry.

The course at the Academy lasts 5 years; at the end of the first 3 years the students are promoted 2nd lieutenants, and they pass out finally as 1st lieutenants. On completion of the course at the Academy the 1st lieutenants visit, under the direction of their professors, such works as may be of practical value to them.

Strength in 1904.—The strength of the Corps in officers in 1904, with the ages and length of service of the senior and junior in each rank, are shown in the following table:—

	Senior.		Junior.	
	Age.	Service	Age.	Service.
Lieut.-Generals (1)	—	—	—	—
Generals of Division (0)	—	—	—	—
Generals of Brigade (7)	—	—	—	—
Colonels (34)	60	44	55	40
Lieut.-Colonels (50)	52	36	44	29
Majors (114)	45	29	42	24
Captains (236)	44	24	27	11
1st Lieuts. (167)	27	11	27	7

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ADMINISTRATION.

Engineer Section of War Ministry.—The Ministry of War has an Engineer Section which deals with the following questions:—*Personnel* and all matters relating to the officers and men of the active and reserve lists of the Corps and individuals belonging to the "Personal del Material de Ingenieros." Engineer material and everything relating to its construction, acquisition and change. Projects for and construction of military works. Appropriations. Depôt of plans and instruments. Technical details and accounts. Statistics relating to buildings. Fortification works in the coast districts, on the frontiers, in the fortresses. Engineer details of defence schemes. Procedure of business relating to all the subsidiary establishments of the Corps Business of the Junta Facultativa de Ingenieros.

Engineer Committee.—The Junta Facultativa de Ingenieros (or Engineer Committee) was created by R.O. of 12. 9. 01. Its object is to inform the Minister of War concerning such technical subjects proper to the services of the Corps as it is consulted about; and especially concerning projects for and the construction of works of defence, quarters and military buildings in general, building materials, and material for the troops and parks. By R.O. of 8. 10. 01 it was directed to draw up regulations for itself, which were approved by R.O. circular of 5. 11. 03.

There is also entrusted to this Committee the duty of proposing to the Minister of War such innovations and reforms as it considers suitable, within the realm of the special technical services whose study is confided to it. It consists of a brigadier-general as president, the colonel director of the Engineer Museum, the colonel of the 2nd Regiment of Sappers, the colonel in charge of the Laboratory, the lieut.-colonel of the Railway Battalion and 1 other lieut.-colonel, with a major as secretary and 3 captains as associate members.

MISCELLANEOUS.

Garrison Duties.—The Engineers as a general rule do not perform garrison duties, except when civil disturbance or other exceptional circumstances make it necessary in the opinion of the G.O.C. of the Army Corps.

Height.—The minimum height of recruits is 1·680 m.; but for the company of workmen, the topographical brigade and balloonists this is reduced to 1·660 m.

Carrier Pigeons.—The Carrier Pigeon service is in charge of the Engineers, the central loft at Guadalajara being an annexe of the Balloon Park. The following military pigeon lofts have been approved, but it is uncertain whether those marked * are in existence:—1 at Madrid; 4 on the French frontier, established at *Figueras, Saca,

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Pamplona, and *Oyarzun (the previously existing loft at Gerona has probably been transferred to one of the two places starred); 2 on the Portuguese frontier at Ciudad Rodrigo and Badajoz; 2 on the coast of Morocco at Ceuta and Melilla (a new station has just been opened on the Chafarinas Islands); 2 in the Balearic Islands at Palma and Mahon; 5 on the coasts of the Peninsula at *Ferrol, *Valencia, Tarifa and Barcelona; and 3 in the interior at Zaragoza, *Valladolid and *Cordoba. The establishment of pigeons (exclusive of that of the central loft) is 400 pairs at Madrid and 100 pairs at each of the other lofts. The Societá Colombófila de Cataluña is bound to place its carrier pigeons at the disposition of the Chief of the Military Communications for manœuvres and field operations.

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THE DESIGN OF TALL CHIMNEYS.

By Capt. A. ff. Garrett, R.E.

Major Ainslie, in his article on the above subject in the June issue of the *R.E. Journal* has called attention to the very different results obtained in tall chimney design according to whether Colonel Scott-Moncrieff's method, Messrs. Babcock & Wilcox's formula or the London County Council rules are followed.

On examining the formulæ, it is evident that the Babcock & Wilcox formula is incomplete, as it merely provides for safety against overturning, and takes no account of the stresses set up in the masonry or as to whether the masonry is strong enough to withstand the stresses so set up. It can therefore only be looked upon as giving a first rough approximation, though possibly it may give reliable results for low chimneys, where the stresses set up will not be very high.

The London County Council regulations are mere arbitrary rules, and are based neither on considerations of safety against overturning nor against excessive stresses in the masonry. They may form a good practical guide, but surely any chimney of any dimensions should be more carefully investigated.

The Scott-Moncrieff method is complete in that it ensures safety against the various ways in which failure may occur; but it appears to err on the side of excessive safety, and gives unnecessarily heavy chimneys. The reason for this lies in the nature of the assumptions made regarding the wind pressure. Thus the pressure set up by the wind is supposed to act more or less uniformly over the whole of a vertical plane drawn through the centre of the chimney, the width of this plane being taken as the mean external diameter of the chimney, and the height of the plane as the actual height of the chimney. The pressure is supposed to be the maximum observed, viz., 56 lbs. per square foot, acting on the whole of this vertical plane; and further, the centre of pressure is assumed as being situated at half the height of the chimney. The overturning moment is then obtained by multiplying the area of this vertical plane by the pressure of the wind (usually taken at 56 lbs. per square foot) and by half the height of the chimney.

Now the resulting overturning moment must be too great for the following reasons :--

(1). It is practically certain that the wind pressure can never be as high as 56 lbs. per square foot on the lower parts of the chimney near the ground.

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(2). Instead of the chimney having a constant mean diameter, it tapers considerably. The moment of the wind is evidently greatest on the top portions of the chimney, and it is just here that the error of assuming a mean diameter for the chimney will make the most difference.

It therefore seems worth while to investigate the overturning moment more accurately.

Stevenson's experiments in wind pressure show that the pressure increases as the ordinate of a parabolic curve, *vide* pp. 234, 235 of *The Principles of Structural Design*. The formula $18+\frac{x}{4}$, where x is the height above the ground in feet, gives results practically identical with Stevenson's. Thus at 50 feet, it gives a pressure of $30\frac{1}{2}$ lbs. as against Stevenson's 30 lbs.; at 100 feet 43 lbs. as against 42 lbs.; and at 200 feet 68 lbs. as against 66 lbs. according to Stevenson. It is proposed therefore to assume the wind pressure as equal to $18+\frac{x}{4}$.

Even this formula will probably give an excessive overturning moment. Sir B. Baker's experiments, carried out during the erection of the Forth Bridge, indicate that the pressure per unit area on large surfaces is considerably less than upon small surfaces. Thus the highest pressure recorded during the seven years the experiments lasted was 41 lbs. per square foot on a small area of $1\frac{1}{2}$ square feet, while on a large area of 300 square feet the maximum pressure did not exceed 27 lbs. The Firth of Forth is said to be exposed to particularly high winds, so probably these figures may be taken as representing the maximum pressures likely to be met with in the British Isles under ordinary circumstances. It must be a very small chimney that does not present a surface of 300 square feet. It therefore appears that the formula $18+\frac{x}{4}$, giving pressures varying from 18 lbs. at the ground level to 68 lbs. at 200 feet, must allow for as great or a greater pressure than is ever likely to be met with in practice. In fact it is doubtful if even an American tornado would develop higher pressures.

Now suppose the chimney to taper uniformly from an external diameter B at the base to b at the top, and let the height be h.

Consider a strip dx at height x.

The width of the chimney at height x is $b+\frac{x}{h}(B-b)$. Therefore the area of the strip is

$$\left[b+\frac{x}{h}(B-b)\right]dx$$

and the wind pressure on the strip is

$$\left[18+\frac{x}{4}\right]\left[b+\frac{x}{h}(B-b)\right]dx.$$

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Therefore the total wind pressure on the whole chimney is (for a round chimney)

$$\tfrac{1}{2}\int_0^h \left[18+\frac{x}{4}\right]\left[b+\frac{x}{h}(B-b)\right]dx \ldots\ldots\ldots\ldots (1).$$

To find the height of the centre of pressure. This is evidently the same as finding the centre of gravity of all the horizontal wind forces acting on the whole area of the chimney; and by the general formula for the centre of gravity is

$$\frac{\int_0^h \left[18+\frac{x}{4}\right]\left[b+\frac{x}{h}(B-b)\right]x\,dx}{\int_0^h \left[18+\frac{x}{4}\right]\left[b+\frac{x}{h}(B-b)\right]dx} \ldots\ldots\ldots\ldots (2).$$

The overturning moment due to the wind will be the product of (1) and (2) or

$$\tfrac{1}{2}\int_0^h \left[18+\frac{x}{4}\right]\left[b+\frac{x}{h}(B-b)\right]x\,dx.$$

Evaluating this, we get the moment

$$M=\frac{h^2}{8}\left\{12\,(2B+b)+\frac{h}{12}(3B+b)\right\} \ldots\ldots\ldots\ldots (3),$$

which is a fairly simple formula readily applicable to any chimney.

Computing the overturning moment by this formula, I have worked out the tension and compression (y and Y) at the base for Major Ainslie's chimneys A and B, and also for three typical existing chimneys, viz., the Edinburgh Gas Works, East London Waterworks, and Smethwick Chemical Works chimneys (see Table below). For purposes of comparison I have also worked out the tension and compression by the old formula, with the result that all five chimneys appear to be unsafe. As, however, the three typical chimneys are examples of successful works which have stood for many years, I think this is a clear practical proof that the old formula gives rise to unnecessarily heavy chimneys.

Looking at the values of Y and y computed by the new formula (3), it is seen that the Edinburgh Gas Works and East London Waterworks chimneys are safe; but that in the case of the Smethwick chimney there is a tension of 2·75 tons per square foot. This chimney, however, is 312 feet high; so that by the formula $18+\frac{x}{4}$ we are assuming a wind pressure of 96 lbs. per square foot at the summit, a pressure never likely to be approached.

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I would therefore propose that formula (3) be adopted for chimneys up to 200 feet in height; that for chimneys from 200 to 300 feet $\frac{3}{4}$ of the value of M given by (3) be taken; and for chimneys from 300 to 400 feet $\frac{2}{3}$ M. Taking $\frac{2}{3}$ M, the values of Y and y for the Smethwick chimney become 15·35 and ·45, which are safe.

Considering Major Ainslie's chimneys in the light of the above, chimney A would appear to be quite safe; but chimney B shows a tension of $2\frac{1}{4}$ tons, and would therefore be risky for an exposed situation. But in a low-lying district, or if partially sheltered by trees or neighbouring buildings, it would probably be safe against most storms.

I have calculated the stresses in the masonry where failure occurred in the St. Louis chimney, which was fractured (by a tornado) 110 feet from the top, where the thickness of the brickwork changed from 13 inches to 17 inches. The result is a tension of 5 tons per square foot, which is evidently unsafe.

In the case of the three typical chimneys, I have calculated the actual weight and given the weight computed by the Babcock & Wilcox formula for comparison. It will be seen that in every case the actual weight is far in excess of that given by the formula. It appears as if the Babcock & Wilcox formula can only be considered as a rough guide for chimneys under 100 feet in height in unexposed situations.

It is claimed that formula (3) gives a method of calculating the overturning moment which is in accordance with recent experiments on wind pressure, and that its reliability is borne out by the dimensions of existing and successful chimneys.

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COMPARATIVE STATEMENT OF CHIMNEYS.

All Units in Feet and Tons.

SYMBOLS.		*h*	B	*b*	W or N	W		I	A	By New Formula. M	By Proposed New Formula. Y	By Proposed New Formula. *y*	By Old Formula. Y	By Old Formula. *y*	
Name of Chimney.		Height = *h* feet.	External Diameter at Base.	External Diameter at Top.	Weight in Tons.	Weight by Babcock & Wilcox Formula.	Inside Diameter at Base.	Moment of Inertia of Base.	Area of Base.	Overturning Moment.	Compression at Base.	Tension at Base.	Compression at Base.	Tension at Base.	Remarks.
Edinburgh Gas Works	.....	100	10	3·5	144	85	5·5	445	54·8	315	6·17	− ·91	7·29	− 2·03	
East London Waterworks	.....	175	18·5	6·25	760	260	11·0	5100	173	2440	8·8	− ·04	13·01	− 4·25	
Chemical Works, Smethwick	...	312	27·2	6·5	2175	755	19·2	20500	292	16400 11940	17·65 15·35	− 2·75 − ·45	21·35 —	− 6·45 —	Reducing M to $\frac{2}{3}$ M.
Major Ainslie's Chimney A	.....	85	8·5	3·5	108	64	—	250	49	181	5·29	− ·85	7·14	− 2·71	
Do. do. B	.....	85	7·1	3·5	79·5	73	3·3	111	29·6	156	7·65	− 2·27	10·1	− 4·7	
St. Louis Chimney, fractured 110 feet from top by a tornado.*		162	17·8	15·6	23·2	—	10·2	2030	58	1150	5·45	− 5·05			

* Above is calculated for section 110 feet from top, where fracture occurred.

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PERSIAN DESERTS AND GARDENS.

By Capt. L. E. Hopkins, R.E.

Persia is a country of contrasts. There is bitter cold and snow and terrific heat; ancient ruins and fine new palaces; the latest form of telegraph instrument may be heard in an old Sassanian palace overlooked by barbaric frescoes of that age; Europeanised Persians, who will chat with you in English, German or French, rub elbows with the Ilyats or nomad tent dwellers.

But what strikes one most forcibly is the contrast between Persia's beautiful gardens and its godforsaken deserts. Anyone brought straight from England and put down haphazard anywhere between Shiraz and Quetta would probably call the place a desert offhand. But there are deserts of all degrees. The treeless barren mountains, and the long stony glacis which lie between them and the valleys and seem so endless and wearisome to cross, present a very dreary appearance for the greater part of the year; but in early spring after a snowy winter these same wastes are covered with short green grass and carpeted with red poppies, yellow tulips, blue irises and crocuses, hollyhocks and all manner of unnamable flowers. Further east, Baluchistan frequently gets no snow or rain in winter and then spring brings with it no grass or flowers; and how all this vegetation manages to lie dormant under such circumstances, sometimes for two or three years, is to all, except perhaps a botanist, something of a marvel.

The real deserts of Persia are the Kavir and the Lut. Possibly these names cover many different aspects of desert, as in all countries names have usually a local significance which varies widely in different districts. Anyone travelling between Shiraz and Kerman will cross the Saidabad Kavir at an elevation of 5,600 feet. It is during summer a plain of pure salt; and in a wet winter it may sometimes become a salt marsh. After passing the Lake of Niriz—the Persian Dead Sea—at the eastern end of which is a Kavir in embryo, one crosses an intervening range of mountains by a pass of about 9,000 feet elevation. The greater part of this range is a sort of no-man's-land, disowned by both the Governors of Shiraz and Kerman; and its few inhabitants, when times are bad, eke out a precarious existence by robbing passing caravans.

From the summit of the pass the track descends a wide valley between high mountains, whose black profiles stand out clear against

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what seems a great white sea stretching away from the bottom of the valley some fifteen miles distant. This is the surface of the Kavir, a pure white, like snow ; it is one of the most extraordinary sights in the world and Persia's speciality. At noon, after a thirty-mile march, its shores are reached and camp is pitched near a solitary mud-walled house and enclosure, and one can readily excuse the surly manners of the people after tasting the nauseating salt water which they must perforce habitually drink. A hot salt wind blows across the Kavir, and the shelter afforded by a solitary locust-stripped tree does little to prevent one's face from being almost skinned.

A start must be made in the early morning before sunrise to get across before the glare of the white salt surface becomes too unbearable. The first four miles of the Kavir is not unlike a fallow field covered lightly with snow or a heavy hoar frost. This efflorescence of salt gets gradually thicker and thicker until, for about four miles in the centre, the salt lies in a layer about two inches thick. It has a perfectly smooth white surface, like a frozen pond covered with snow, stretching away to the horizon as an unbroken glistening plain. On the track the surface is quite solid, but it is dangerous to go far off it ; one can see the tracks of camels which have strayed off the road, getting deeper and deeper in the salt slush beneath the hard surface the further they went. The solid salt ice gradually gives way again to the salt-frosted ground, and in about three miles more the fertile valley of Saidabad is reached.

The whole bed of the Kavir was no doubt at one time an inland sea, such as is the existing lake Niriz. The rainfall of Persia diminished along with the deforestation of the country, till eventually there was not sufficient to replenish the loss by evaporation from the surface of the lake.

The common Persian word for desert, whether Lut or Kavir, is *biabun*. Whatever may be the derivation of the word its very sound seems to call up visions of the most desolate place on earth. But the Lut is very different from the Kavir. The road from Kerman to Sistan or Sarhad crosses the extreme south-east corner of this great desert, which stretches many hundred miles straight away to the north of Persia. After leaving the delightful climate of Kerman the road to Sistan crosses the Hanaka Pass at a height of 9,000 feet, and then there is a long descent of nearly 8,000 feet to the bottom of the Lut at Shurgaz, the route passing Bam, a large town with a Sub-Governor under Kerman.

Fahraj is the last village on the road and a few miles further on begins the Lut, a bare plain of black gravel and grit. In direct contrast to the dazzling white of the Kavir, the general tone of the Lut is a dead black. Every ten miles or so a belt of low tamarisk jungle straggles across the plain, and here and there are dotted solitary thorn trees of grotesque appearance, perhaps a dozen in view at any one

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time. Track there is none, and only guides who know the landmarks can find their way, and then only in daylight. Nadir Shah, who crossed this desert on his way to and from India, built high towers, visible at a distance of 20 miles, to guide his troops; and no doubt beacon fires were lighted on them at night; they still form conspicuous landmarks.

Except near Shurgaz there is very little drift sand, and for miles one can ride in the dark without coming upon anything to make a horse stumble. During July and August a strong N.W. wind blows incessantly, driving before it the sand and grit, which beat against the side of a tent like rain. The heat probably never exceeds 115° F. in the shade, which is of course nearly 10° less than in the desert between Baluchistan and the Indus; it is a dry heat by no means oppressive, but still under the conditions it is quite bad enough.

For a hundred miles there is no drinkable water. At Shurgaz a water hole, some ten feet deep, supplies a muddy brine wriggling with insects, at which even a camel looks askance. At Maizar Ab one sees what is apparently a charming sparkling spring, surrounded by short green grass; but on a closer inspection the water, besides being salt, proves to be strongly impregnated with sulphurous gas, and the grass is too hard and spiky to sit down on. At Rud-i-Mahi, 50 miles from Shurgaz, a pleasant-looking stream turns out to be undrinkable brine. High up in the mountains of Sarhad, 4,000 feet above the sea, is the first spring of sweet water, bubbling up in the bottom of a valley and shaded by high tamarisks.

Beyond Sarhad again, on the farther side of the range of mountains separating Baluchistan from Persia, another 200 miles stretch of Lut lies on the road to Quetta. But here there is a good road, with every luxury at the staging bungalows built by the Indian Government; and as the country is seldom below 3,000 feet above the sea, the heat is not nearly so great. The water too is by no means impossible, though very upsetting to most people who drink it.

Gardens form a more pleasant subject. Persians seem to have a happy knack in designing a garden, a sort of natural artistic feeling for it. Though they have many unlovable characteristics, only to be classed with those of Armenians, they can do two things well; they make beautiful carpets and charming gardens. The older the carpets the better, and the older the gardens the more delightful.

Persians are nothing if not hospitable; and no one who has enjoyed the pleasure of camping in some rich Persian's garden, after a long hot march through that glaring dusty country, will be ever likely to forget it. You spread your carpet on the banks of the stream, and

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lying on your back stare up into the green depths of the chenars* above you, and so get rest for eyes that have been screwed up all day in the glare of the sun. By your side you may have a bowl of sherbet cooled by a large lump of snow from some neighbouring mountain; to eat there is a choice of peaches, cherries, apricots and melons; and you may enjoy yourself and forget that you are 5,000 miles from home.

In some gardens may be found a central pavilion with vaulted roof; the inside, by means of intricate mouldings in white plaster, is made to appear both light and cool. The floor will be richly covered with a thick white felt rug from Ispahan or Yezd, while everywhere the air is heavy with the scent of abundance of roses, such scent as you will never find anywhere but in Persia.

Such gardens as these exist all over Persia wherever a sufficiency of water can be obtained and far from the chief cities. But the most beautiful are to be found at Shiraz, where Hafiz and Sadi and Omar Khai-yam, assisted no doubt by the local wine, found inspiration for some of the best poetry that has ever been written. Shiraz still produces an excellent wine, not unlike sherry in taste and appearance; but the modern Persian prefers to jog his imagination with some of the toughest European brandy he can obtain or with the strong spirit which Armenians and Jews distil for them locally.

Persian gardens are all arranged very much on the same plan. A stream flows through the centre and at the upper end is the owner's villa. The water runs through the ground-floor rooms of the house in an open channel and keeps them cool. Just beyond the house the stream empties itself into a large stone tank, and thence flows down a central avenue of chenars, feeding on its way the small channels which irrigate the fruit garden. Round the tank are the flower beds and shady paths among cypress trees.

Of the many gardens round Shiraz, Dilgusha, which lies close to the tomb of Sadi, is one of the best. Here one is delighted by the rich colours of the house toned down by time to the most charming tints, and the air is loaded with the scent of orange blossoms, pink and white oleanders and roses. Among the other gardens may be mentioned Bagh-i-Takht, now falling into decay. Here there has once been a fine avenue of chenars along the entrance road, but now only stumps remain. The house is remarkable for being built in tiers on the hillside, the water falling in cascades through the buildings into the tank below. The tank is one of the largest in Shiraz, about 100 yards square, and on it are the remains of an English rowing boat, no doubt built by some former officer—perhaps a Royal Engineer—of the European Telegraph Company, who have a large office in Shiraz. The Bagh-i-Iram has some fine cypresses and in the cool halls of the

* The chenars of Kashmir or Persia are hardly recognisable in the stunted plane trees of the Thames Embankment.

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villa one could enjoy life for a time even in Shiraz. Here too the floors are covered with immense felt rugs nearly an inch thick ; the colours are dark brown with a pattern in blue wool pressed into the surface. These felts are quickly destroyed by moths and insects, or they would soon find as ready a sale in Europe as the best Persian carpets.

The above gardens all lie a short distance outside the town, and in the cool of the evening it is the fashion for the young bucks of Shiraz to ride out on their prancing ponies to one or other of them. They usually carry guns or rifles and are followed by an armed servant or two ; and all the evening one is continually hearing shots fired in the air by these bloods in mere exuberance of spirits. They are really the most harmless creatures who would never shed blood except by accident. They are not, however, overburdened with manners, although they are bursting with polite phrases. They like to gallop past a *Farangi* to kick up the dust in his face if on foot, or in the hope of frightening his horse if riding. A Pathan would call them *zenani* (effeminate) without hesitation.

The older men and the rich *mullahs* will spend the afternoon visiting some friend, and then perhaps move on to some shady spot in the gardens and spend the evening over sherbet, tea and the *qualyan* (hookah or pipe) in endless rotation. Sometimes too their dinner will be brought with them by their cook, mounted on a pony with the most wonderful saddlebags in front and on each side, stuffed to bursting with plates, dishes, food and, no doubt, plenty of wine. Behind the cook comes the pipe-bearer, mounted with all his smoking paraphernalia on another pony, quite an unique sight. In front of him are two huge holsters, 5 inches in diameter and nearly 3 feet long, in which are the *qualyans ;* and hanging by chains from the saddle are a brazier of live charcoal, so arranged as to prevent the charcoal falling out, and also various other implements. The *qualyan* requires lungs of brass and of large capacity ; you must inflate your whole lungs with the smoke in order to get sufficient draught to make the moistened tobacco burn. The *chibouque* on the other hand is not unlike a clumsy English pipe with a stem like a desk ruler ; you cannot put the stem inside your mouth, but must apply your mouth to the end where the smoke comes out ; it makes a fair substitute for an English pipe, if smoked with the light Tabriz tobacco, the peculiar sweet and scented taste of which is very seductive.

Its gardens will perhaps some day, when a railway has opened it to the globe-trotter, make Shiraz one of the show places of the East. At present it is shut off by 180 miles of difficult mountain track from its seaport Bushire, than which one could probably find few less attractive spots on earth.

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THE QUESTION OF WALLED ENCEINTES.

By Capt. H. F. Thuillier, R.E.

In the June number of the *R.E. Journal* there appeared a translation of an article* in which the opinion was advanced that the fortress of Port Arthur could have held out longer if it had possessed a continuous walled enceinte, and the conclusion was drawn that this siege illustrates the necessity for such an adjunct in modern fortresses. The article is in the form of a review or criticism of an article by another writer in the *Cologne Times*, in which the opposite view was upheld.

The author of the review rightly emphasizes the fact that a fortress does not properly fulfil its object if it requires an army to defend it; but that its defences should be so designed that they can be held by a minimum garrison, thus leaving the great bulk of the army free to undertake the far more important duty of meeting the enemy in the field. This is eminently true, though it does not appear from the extracts quoted from the criticised article that its author was ignorant of this leading principle.

The reviewer continues to say :—" The essential difference between the tactics of a field army and those of a garrison is this :—The field army can oppose large reserves to an attack on any point, and can, by their skilful employment, render nugatory the enemy's success if he breaks through the line. The garrison has no such reserves of men ; it has to use instead a reserve of fortified works in the shape of an inner line, which can be held by a relatively small number of men. This is the true function of the walled enceinte."

Here, if I may venture to say so, it would appear that the premise is unsound and further that the conclusion does not follow from it. Many high authorities consider that, however small the garrison of a fortress, a portion can, and should, always be set aside as a reserve. Even however if this were not so, it would prove the necessity for a second line of defence, but not that this line should necessarily take the form of a continuous walled enceinte.

The author's conception of the functions of an enceinte is given as follows :—" It is a mistake to suppose that the enceinte does not become useful till the girdle forts are captured, or that its only use is

* *Port Arthur and the Question of Walled Enceintes*, by Lieut.-Colonel Frobenius, in the Berlin *National Zeitung* of 11th February, 1905.

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to oblige the enemy to begin his attack afresh after he has penetrated the girdle. It has long been recognised that the defender must put his whole strength into the defence of the forts, and must not attempt to reserve any portion of his force for the defence of the enceinte. The enceinte could not in any case hope to hold out for long after the loss of the forts. The principal *rôle* of the enceinte is played during, and not after, the fight for the possession of the forts." The last two sentences of the above should be noted in view of what comes after. What this *rôle* consists of is explained by the author further on. "The 'assault-proof' enceinte may be slenderly garrisoned, in view of the serious hazards to which the besieger would be exposed if he ventured to attack it. Its principal use—and that a most important one—is to strengthen the fighting line during an attack on the girdle, both by its material and moral support, and not merely as a place where the defenders can make a last stand when the girdle has been captured by the enemy."

It is difficult to comprehend what possible "material" support to the fighting line can be afforded by an enceinte which is situated 1½ miles or more in rear of it; its "moral" influence is more comprehensible, and its effect in this direction, according to the theory entertained by the author of the article under review, is illustrated by his assumption in regard to what happened at Port Arthur, which is as follows:—"The defender need not have expended so many lives on holding unimportant advanced works had not the *absence of an enceinte* kept him in a state of anxiety lest all should be lost if the besieger succeeded in penetrating the girdle. He was therefore forced to keep masses of troops in reserve behind all the outer forts, ... These troops were exposed to severe fatigues and heavy losses. As at Sebastopol it was impossible to provide them with proper protection, either against the weather or against the enemy's fire, so that they filled the hospitals with sick and wounded. As a result, the defending forces were used up more quickly than if a walled enceinte had existed. An enceinte would certainly have enabled Port Arthur to hold out longer."

In the first place it may be remarked that a state of anxiety, and the actions consequent on such a state in the mind of a commander, are the results of the mental condition and temperament of the latter, and are not necessarily dependent on the form of the works. If the defending commander is imbued with the belief that in a walled enceinte alone can salvation be found, he will doubtless be a prey to anxiety should he be so unfortunate as to be called upon to defend a fortress unprovided with this adjunct. If on the other hand he has no faith in walled enceintes, but believes that a second line of well-planned earthworks, provided with suitable obstacles in their front, together with a good organization for the concentration of force upon the threatened point and for the delivery of a prompt counter-attack

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by intact reserves in the event of the outer line being penetrated, are sufficient to render the heart or kernel of his fortress entirely secure from assault, he will, if he has been careful to provide all the above resources, suffer no anxiety whatever on this score.

Further, we do not know what authority the author has for his statement that the absence of an enceinte produced a state of anxiety in the mind of General Stoessel and led to the other results referred to. Indeed it is difficult to reconcile this observation with the author's opinion previously quoted that an enceinte cannot in any case hope to hold out long after the loss of the forts. Why then should its absence add appreciably to the anxieties of the defender? Is it not a good deal more probable that in the case of Port Arthur the defender's anxiety and his efforts to keep large reserves close up to the outer forts arose from a knowledge that the positions occupied by the latter dominated those of the interior works and even in some cases the town and harbour themselves. This alone,—and, as far as can be judged from the scanty information at hand, it seems to have been the case,—would be enough to cause the anxiety and necessitate the special efforts above described. The existence in such circumstances of an enceinte commanded from the captured outer works would not, after the loss of the latter, have delayed the attackers for long. In fact it seems evident that the evil to which the author draws attention, namely the losses among the reserves behind the outer works, would have been more directly and economically obviated by the provision of good covered shelters at those places rather by an enceinte.

While, therefore, we may admit, as a general principle, that a second line of defence is always desirable and often essential, it does not appear that any of the arguments advanced in the article under review are such as to convince us of the necessity for this line taking the form of a continuous walled enceinte. This question in fact is but another form of the long-contested one of the two schools of thought as regards the form of defensive works generally; the old school insisting on the necessity for masonry, concrete and steel protection, for deep ditches, walled escarps and flanking caponiers; and the new school relying on earthworks of low profile and shallow trace, on invisibility, mutual support and intercommunication, on freedom of tactical action and good organization.

We need not enter into the arguments here. So little has been published up to date of the details of the siege and defence of Port Arthur that we can hardly yet draw any reliable conclusions therefrom on this subject. There is, however, one point to which it is at least worth while to draw attention, as it tends to throw some light on the contested question referred to above. The defensive works of a land fortress have up to the present been designed to resist the projectiles fired by ordnance of siege type; and till lately the largest

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pieces mounted on travelling carriages in any army, and therefore the largest against which resistance was contemplated, were up to 6-inch and 8-inch calibre only. We know that the Japanese brought to bear on the works at Port Arthur weapons of 11-inch and 12-inch calibre. It is true that they enjoyed special and unusual facilities for the transport of such heavy ordnance in the possession of a sea base in close proximity to their siege lines; although, on the other hand, the difficulties to be overcome in their transport from Dalny to the places where they were used were great. But who can deny that, with the growing improvements in methods of mechanical transportation which we are now witnessing, such ordnance will be the rule in all future land sieges between first-class military powers. In that case, in the long contest for supremacy between defensive material and battering artillery, the latter will have secured an advantage which, when aided by the powerful explosives of the present day, it will be difficult, if indeed possible, for the former to neutralize.

What would have been the effect at Port Arthur of the concentration of the fire of a number of guns of this size upon the point selected for assault in a supposititious walled enceinte? How long would the defenders of the latter have remained at their posts under the showers of concrete and bits of masonry which would have been sent flying in all directions under the action of the Shimosé shells? How long would the works have remained "storm-proof" and the obstacle "insurmountable?" These reflections are not likely to convert to a belief in continuous walled enceintes, masonry ditches, etc. those who previously held opposite views. They seem in fact likely to point rather to the conclusion that, with the increased power of mobile artillery,—or the increased mobility of powerful artillery, if it is preferred to put it that way,—such forms of defence are likely to be less effective than ever.

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MEMOIR.

COLONEL C. H. LUARD, LATE R.E.

COLONEL CHARLES HENRY LUARD, R.E., who died on the 10th July in his 69th year at his residence in London, passed out of the Military College, Addiscombe, in 1855 as first cadet of his year, winning the gold Pollock Medal and the Sword of Honour. Sir Colin Scott-Moncrieff, his lifelong friend, writes of him: "He was the most brilliant and cleverest of all my contemporaries."

In 1857 he started for India with other cadets in a sailing ship round the Cape, and had the remarkable experience of being becalmed for 28 days between Madras and Calcutta. His service of 32 years in India was mainly in the Railway Branch of the Public Works Department; and he retired when Consulting Engineer to the Government of India in 1890, on being offered the post of Engineering Inspector to the Local Government Board, a post he held for 12 years. On occasions he was detached for special duties, viz., an expedition from Burma to China, Under Secretary in the P.W.D., and Master of the Calcutta Mint. In England he was employed by the Secretary of State for War to visit and report on a system of railway construction in Germany; and by the Secretary of State for India was appointed a delegate to the International Railway Congresses held at Brussels, 1885, and at Milan, 1887. At the time of his death he was a Director of the Southern Mahratta Railway.

The present writer was an intimate friend of Colonel Luard. The sorrow, the shock, the sympathy evoked by his sudden and beautiful death cannot be expressed in words. The regard and admiration which he inspired in those who knew him well, whether old or young, was enthusiastic. Many-sided in his interests, able and cultivated, with a firm grip upon all he knew, he was a distinct personality.

His nature was eminently social, his sympathies singularly varied and fresh; so that the younger generation found him keenly alive to their hopes and interests, and even when he disagreed they felt his views were the outcome of an active and working mind, not merely the inert opposition of an older generation to new ideas.

He was certainly critical; and very staunch to his fundamental convictions as to conduct, uprightness and integrity. "I always felt,"

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writes a friend, "his thoroughness and whole-hearted regard for truth did one so much good"; and another writes "His example and advice were always to be followed; the latter because it was always practical and hopeful. Indeed it seemed to be his greatest happiness to try and help others."

He was tall, well-built, active, and good at all games. No account of him would be complete without allusion to his love and just appreciation of art, and to his own great power as an artist inherited from his father. In the year 1857 he had become acquainted through his brother John (who had retired from the army to become an artist) with the group of young painters the founders of the Pre-Raphaelite Society. Millais, Holman Hunt, and the Rossettis he knew intimately and gained the lifelong friendship of many of the interesting men associated with that Society, and his love of art, and the keen interest he took in all the manifestations of it, never forsook him.

Of Huguenot descent in an unbroken line he was by heredity and instinct a Liberal, and unlike most men became more Liberal as he grew older. "It always seemed to me," writes one of his younger friends, "that he had that alertness of mind which never grows old."

The following amusing incident of old Addiscombe days is told by Sir Colin Scott-Moncrieff to show Luard's readiness in an emergency. "In the spring of 1855, when he was senior cadet and first corporal, the Queen and Prince Albert with the Emperor and Empress of the French visited the Crystal Palace in State. The Crimean War was then at its height and there were French military bands and much excitement. Some 120 of us cadets were there, mere units in the crowd and powerless to get to the front to see the fun. Suddenly Luard shouted 'Addiscombe cadets, fall in.' We did so, and shoved our way through the crowd which, supposing us part of the show, made way, when he marched us triumphantly alongside the Royal carriages."

AN OLD FRIEND.

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TRANSCRIPT.

PREVENTION OF DAMPNESS DUE TO CONDENSATION IN MAGAZINES.*

THE United States Army has for the last few years been carrying out, at considerable expenditure, numerous experiments in reducing and preventing dampness due to condensation in magazines. Various methods have been tried in every port of the United States with, in many cases, considerable success; and, as the subject is of great professional interest, a short epitome of the experiments may be useful to officers of the Corps.

The magazines were all originally constructed of concrete; but it appears that at first no damp proof courses were laid, nor were any steps taken to prevent percolation through the concrete. These defects were remedied later and the leakage prevented.

The problem of preventing condensation, however, remained to be solved. A considerable sum of money was therefore set apart for special experiments in this direction. From the reports sent in, lining the magazines with porous brick gave the best results; various brick linings were tried, such as hollow bricks, book tiles, "Shawnee" brick (a special class of brick which is said to absorb water like blotting paper). In some cases a 4-inch air space was left between the lining and the concrete; in other cases this was omitted. Provided that the bricks or tiles were not too hard burned, all were very satisfactory.

The ceilings were in some cases lined with brick arches, but the bricks being necessarily harder burned showed traces of dampness. In one case a ceiling (below a concrete roof supported by I-beams) was made of plaster in the proportion of 1 barrel of cement to 2 barrels of slaked lime. This was laid on metal lathes, the surface of the plaster being left as rough and porous as possible, and was entirely effective in preventing condensation. Drains were usually made inside the magazines.

Copper lining with magnesia lumber did not prove effective; it was noticeable however that, when copper lining held in place with pine planking was tried, condensation was considerably reduced; and in some magazines, where the doors had been kept closed, the rooms were quite dry.

Another successful form of lining tried was as follows. A magazine was first of all thoroughly dried and cleaned; a heavy coat of bitumen

* The information is taken from the *Extracts from the Annual Report of the Chief of Engineers, United States Army, for* 1903 and is communicated by the Director of Fortifications and Works, W.O.

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and tar was then applied and thoroughly rubbed in. A second coat was also applied to the walls for a distance of 2 feet from the floor. Two thicknesses of tarred paper, with magnesia boards fastened on the top, were then placed on the ceiling, which had a lining of copper; magnesia lumber was fixed to the angle irons which supported the copper roof. The magnesia lumber was painted with two coats of "Gypsine," followed by one of "cold-water paint." Floors were relaid with concrete and given ample pitch towards the drains. The magazine is said to have been sometimes dripping wet before the lining was put in; subsequently there was no condensation and the room was quite dry, except for a slight indication of moisture near the bottom of the wall where the concrete was thickest.

A lining of "Paroid" roofing paper (a species of waterproof paper) was tried, but was not at all successful and did not reduce condensation.

Compressed cork linings were unsatisfactory.

Wooden plank linings were also ineffective.

Corrugated iron and lead linings were also experimented on, but with indifferent success.

Another successful lining was that of asbestos lumber, held in place by brass screws screwed into wooden plugs driven into holes in the concrete. The ceilings and walls were first heavily coated with asphalte; the ceiling was then lined with 16 oz. copper plate and the walls with "Paroid" felt, after which the asbestos lumber was applied.

A further method, which answered well, was to place hot melted paraffin wax on the concrete roof, side wall and floors, the surface thus treated being made as hot as possible by the use of a kerosene blow torch. The iron roof beams were embedded in concrete and hot paraffin placed on the outside surface. Soft white-pine ceilings and side walls with hot paraffin on the upper surface of the ceiling were fixed, and deadening felt and white canvas were fastened to the outside surfaces with copper tacks, leaving an air space all round. New concrete floors were laid with gutters on outside edges; these were paraffined, and deadening felt and soft white pine flooring, paraffined on the outside, laid on the top. Before this lining was commenced the condensation was described as "enormous"; subsequently when other rooms in the battery were wet, this one remained dry.

The experiments bear out the general principle that there can be no condensation, if the escape of enough heat into the walls from the air in contact with their surfaces can be prevented.

The following is a nearly full extract of an interesting answer given by Major W. L. Marshall, Corps of Engineers, the officer in charge of the Defences of New York Harbour, to the question "How may we secure well-protected dry service magazines for our powder and projectiles?"

Report of Major W. L. Marshall, U.S. Engineers.

"These rooms or storehouses are far withdrawn from the open air, due to the necessity for so placing them that the contents may not be reached by the projectiles of the most powerful modern guns. The rooms are

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caves, with the temperature of walls naturally about the same as the mean annual temperature at their location.

"In summer, on our sea-coast, the air is not only at high temperature but is also highly charged with moisture; and when admitted into these rooms, has its temperature rapidly reduced and gives up its moisture in great part as 'condensation' on the walls and on any bodies, like powder cases or projectiles, stored therein. This reduction in temperature of the air admitted from the outside and deposit of moisture therefrom are of course represented by a heating or rise in temperature of the walls of the rooms. If air in sufficient volume, or in excess of the quantity that may be cooled to below the dew point while in contact with the walls, is admitted and passed through the room before it be cooled to the dew point, no deposit of moisture will take place; while at the same time the walls of the room will be heated to an extent measured by the loss in heat units of the air passing through the room. When this current of air is sufficiently prolonged, the walls of the room will be heated up to the mean temperature of the outer air; or, if the circulation be controlled in such manner that air is admitted only during the rise in temperature after sunrise, the walls may be heated much above the mean temperature; and if this ventilation be properly managed no trouble from condensed moisture may be feared.

"On the other hand the quantity of moisture at any time contained in a room full of air is limited. Only so much moisture may possibly be derived from it. If the room be sealed to prevent any more air entering, then it will remain dry or approximately in the same condition as when sealed; no more moisture and no more heat can enter or be abstracted from it by convection. Dry store rooms then may be secured in two ways without artificially heating them:—

First. By free ventilation at the proper time.

Second. By keeping them practically sealed when condensation on cold walls is probable.

"Should the room (with its concrete walls at about the mean annual temperature) be imperfectly ventilated during the moist warm months, *i.e.*, should air be admitted at rates and in volume so small that it may be reduced below the dew point while in contact with the cold walls, the room will be kept reeking with condensed moisture so long as the conditions exist.

"In nearly all the emplacements in this district, constructed prior to 1900 and provided with ventilating pipes the ventilators are small (6 inches or less in diameter), leading vertically from the rooms. They are intended to be always open, and are therefore suited for the slow, continuous, pernicious movement just described, depending solely upon differences in density of air within and without the room. As cold air slowly passes out, warm air replaces it, generally through the same orifice, but in different directions of flow, simultaneously.

"Pure air, indeed, is provided for by such ventilators; but they act rather for irrigating than for drying the rooms, and we have been compelled to stop them up in many cases.

"This method of ventilation, due to differences in density in a column

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of air produced by differences in temperature, has been for years applied for irrigation in certain parts of the West, where the returns from the lands irrigated by the system justify the expense of applying it.

"This system of irrigation, as far as I have been able to trace it, was discovered by accident when drainage of lowlands near Chicago for truck gardens was attempted some ten years ago.

"In this system parallel and intersecting lines of porous agricultural tile pipes are laid, buried not too deep to be reached by the roots of vegetables, nor beyond the reach of cold penetration from above, but their ends at very slightly different levels.

"Both ends of pipes, or tiles, are left open during the winter, and the earth above and around the pipes is frozen. In spring the pipes are all closed, except so far as necessary for drainage. Drain pipes are closed at higher and opened at lower ends.

"Whenever dry weather sets in the pipes or tiles are opened. Warm air enters by gravity, and cold air flows out in equal volume at the lower end (the length of pipe being empirically fixed), and when reduced in temperature below the dew-point deposits of water are made, absorbed by the porous tile, and eagerly appropriated by the roots of growing plants above.

"In some of our works we see all this paraphernalia in somewhat different form, all intended for drying caves, but in accord with effectual irrigation schemes. There is in evidence in each case the slow ventilation by currents to and fro through one orifice, caused by changes in weight of air due to changes in temperature, with walls reeking with moisture condensed thereon. We have also the counterpart of the porous tile in the porous lining of walls, meant to absorb the condensed moisture, but we have provided no means to take up and remove this moisture. But if during the period of no condensation the previously condensed moisture be evaporated from these porous linings, and if during the moist weather condensation against these linings be readily absorbed and hidden, then such linings will be apparently dry, although when condensation is going on they are just as wet as if no absorbent had been supplied. The water is still there until evaporated, failing which removal by evaporation we will ultimately have supersaturated non-squeezable sponges filled with water and worthless as further absorbents of moisture.

"Water or moisture should not be merely concealed by temporary absorption, but should be permanently removed and all evidences of it prevented. Such removal does not merely mislead, and is believed to be possible in nearly every case.

"The rules in vogue for avoiding the defects of this method of ventilating magazines simply increase the trouble and have generally failed.

"Some insist that magazines should be opened only when the outside air is at a lower temperature than the magazines. The application of this rule increases the capacity of the walls to condense moisture by continually lowering their temperature. Others demand mathematical determinations of the dew-point temperature, and provide that magazines shall not be ventilated when the temperature of the walls is below this

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dew-point. The dew-point is constantly changing and the rule nearly impossible of application.

"It appears that all these methods and rules should be cast aside, at least so far as to allow methods of ventilation to be provided on the broad principle that air when not saturated will absorb and remove moisture at any temperature, and if passed over objects, masses or walls in sufficient volume will soon reduce these walls to the same temperature as the air.

"Such free ventilation has been attempted in this district, so far with sufficient success to show the principles to be correct and easy to apply, at four emplacements for 12-inch guns at Fort ———— and two emplacements for 12-inch guns at Fort ———— ; but the ventilators might have been increased in size and number advantageously. The results are vastly superior to any attempts on the other system.

"It may be observed anywhere that when a wind encounters an obstacle like a plane surface it piles up against it on the windward side, and a partial vacuum is produced on the lee side. If there be a hole in the surface the wind pushes air through it.

"If the obstacle be a house, the pressure on the windward side will push air through every crack and aperture into the house, if there be any path of egress in the direction of the wind; and this pressure, aided by the suction on the lee side of the house, will cause the air to flow from the house through every aperture and crack on the lee side, and there will be a continuous motion from windward to lee side of the house.

"If windows on windward and lee sides of the building be opened, a much stronger current will pass through the building, whatever be the relative positions of the windows. Curtains will blow inward on the windward side and outward on the lee side.

"On very cold nights, with temperatures approaching zero, without opening doors or windows on windward side of my house, upon opening quite wide a window on the lee side I have observed a stiff current outward, and that the room was cooled by air transmitted through the house from the windward side entering through various small apertures rather than by inflow of heavier air from the lee side.

"It would be instructive, on the other hand, to note the effect of ventilating a tightly closed room by a vertical pipe through the centre of the ceiling; or, on a small scale, the ventilation of a barrel through its bunghole in comparison with its ventilation through similar holes lying in the direction of the wind, one in each head; or the ventilation of the hold of a ship through a single pipe or two pipes abreast, all other openings being closed, compared with fore-and-aft ventilation through two or more ventilators separated the length or width of the ship measured in the direction of the wind current.

"The ventilator flumes used at these emplacements are 18 inches in diameter, each arranged with a tight hinged covering in order that ventilation may be controlled from outside the batteries, and so arranged that rain cannot follow the flues into the rooms. There is only one flue to each room, which has proved sufficient, but an increase in area or number is desirable and practicable.

"The movement of the air through the rooms of the batteries is from

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the doors and windows at the parade wall in rear to and through the flues in front of the rooms, or the reverse; and when the wind is blowing across the battery at about 10 miles an hour and the doors and ventilators opened, the air in the rooms is replaced once in about one and a-half hours and kept in motion by the 'draught.'

"In this system the rules to be followed are:—

A. The rooms to be kept closed

1. Generally throughout the winter, unless on days when there is a brisk breeze and clear weather, and the temperature well above the mean annual temperature.
2. When it is still or calm weather.
3. When the air is filled with fog or mist.
4. Generally at night and after 2 p.m.

B. The ventilation to be free

1. Whenever there is a wind exceeding 5 miles an hour blowing across the battery, and the temperature is above mean annual temperature with no fog, mist or rain accompanying.
2. When there is an appreciable movement in the air, the temperature not too low, and the days clear, the ventilators may be opened between daylight and noon.
3. After the temperature of the walls is sufficiently raised, the ventilators may remain open during all of every day in summer, when air is not unusually moist.

"Free ventilation is especially prescribed whenever a wind of proper temperature is from the land and of good force, day or night, in clear weather. No instruments or calculations required, but the ventilators must be of sufficient capacity to maintain a 'draught' or motion in the air through the rooms during a brisk wind.

"It must be kept in mind that 'ventilation' under this system means an application of the force of the wind to convey heat to the walls and to remove moisture from the rooms by absorption and convection by the air or wind currents—not simply 'aeration' or the supply of oxygen for breathing purposes.

"In providing for this system the ventilators should be of large capacity, and so placed that the rooms to be dried or ventilated, and the ventilator flues, should be as near as practicable along the direction or pathway of the resultant winds during the months from March to September inclusive, with as few changes in direction as safety to contents of rooms against fire or projectiles will allow."

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NOTICES OF MAGAZINES.

Monthly Notices of Royal Astronomical Society.

June, 1905.

This number contains extracts from a report by Major P. B. Molesworth, R.E., of Observations of Mars, which were taken by him in Ceylon in 1903 with the assistance of Lieut. J. S. Barker, R.E.

In consideration of the great amount of work on the details of the planet, which the report represented, the Council decided to place the complete manuscript in the Society's Library, and to print only the principal tables and general conclusions.

The extracts, which are accompanied by photographs, form most interesting reading.

Nature.

July.

Submarine Navigation (*p.* 210).—Sir W. White, in a lecture at the Royal Institution, states that its first practical application to war was made by Bushnell about 130 years ago; but the type soon died out of use in consequence of the conditions which then prevailed in regard to materials of construction, propelling apparatus and explosions. Advances in engineering and metallurgy have made it possible to increase the dimensions, speed and radius of action of submarines; their offensive powers have been enlarged by the use of locomotive torpedoes and superior optical arrangements for discovering the position of an enemy. But no new design has been discovered, and it is clear that Bushnell provided for the governing conditions in regard to buoyancy, stability, and control of the depth reached by submarines. All submarines are left with a small reserve of buoyancy when brought into the diving condition, submergence being affected by the action of horizontal rudders controlled by men within the vessels. Submergence only continues so long as onward motion is maintained; the smallest reserve of buoyancy should always bring a submarine to the surface when her onward motion ceases, and, as a matter of fact, in the diving condition that reserve is very small, amounting to only 300 lbs. (equivalent to 30 gallons of water) in vessels of 120 tons total weight. Safeguards against foundering have sometimes been provided by fitting detachable ballast,

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the more commonplace plan being to make arrangements for rapidly expelling water from the tanks by compressed air, of which there is always a supply ready for the use of the locomotive torpedoes. When a vessel is diving under the action of her longitudinal rudders, she is extremely sensitive to changes of trim; as the under-water speed is increased the pressure on the rudders for a given angle increases as the *square* of the velocity, and sensitiveness to change of trim becomes greater and much skill is required on the part of the operators. For this reason, while speed at the surface will be increased, under-water speeds will not grow correspondingly.

Periscopes at present are not satisfactory, though it is asserted that when the lenses are subjected to a thorough washing of wave water they remain efficient.

Hitherto, submarines have only been armed with torpedoes, and are practically helpless at the surface when attacked by small, swift vessels; but it has been proposed to add guns, and this can be done, if desired, in vessels possessing larger freeboard, though, of course, at increased cost.

Surface boats resembling submersibles in many respects but without the power of diving are in favour with many persons; they would be so constructed that by admitting water into special tanks, they could be deeply immersed and show only a small target above the surface when making an attack. There would be no necessity in such boats to use electric motors and storage batteries, since internal combustion engines could be used in all circumstances.

SOLAR ACTIVITY (*p.* 279).—The "maximum" character of the present epoch is being well maintained. On 13th July two groups of spots, one of them extending over 100,000 square miles, could be seen by the naked eye, this being the second occasion during the present year on which two naked-eye groups have been on the solar disc simultaneously.

THE LATENT IMAGE (*p.* 308).—Professor Joly discusses the nature and mode of formation of the photographic image, and concludes that the recent addition to our knowledge of the electron as an entity taking part in many physical and chemical effects should be kept in sight, in seeking an explanation of the mode of origin of the latent image. The paper is well worth reading.

"THE MECHANICAL HANDLING OF MATERIAL" (*p.* 290).—This book* will be useful to all engineers and architects who have to design machinery or erect warehouses; it gives the latest knowledge as to the mechanical handling and transport of the immense quantities of raw materials used daily in our industrial life. The system of band conveying and the automatic throw-off carriage for such conveyors, now used in the Liverpool Docks, are described in detail. Vibrating trough conveyors, especially useful with any material which would deteriorate by rough treatment, are dealt with. Tightening gears, power required, and speed of travel in the different types of conveyors, and the various types of

* By G. F. Zimmer. (25s. Crosby, Lockwood).

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pneumatic elevators, are discussed. Illustrations of conveyors which have been designed for special purposes, such as timber conveyors, hot coke conveyors for gas works, and casting machines for use with large blast furnaces are given. Aërial ropeways, as used in the building of the Beachy Head Lighthouse and in the rapid completion of that remarkable bridge which will convey the Rhodesian railways over the great gorge of the Zambesi, and the interesting question of the coaling of ships at sea are fully explained.

FERRO-CONCRETE (*p.* 213) is much used in Belgium. The handsome dome of the new station at Antwerp is a prominent instance. The structure, 1,800 tons in weight, rests wholly upon the columns at the angles of the glass lights; these columns are Y-shape in cross section. The external shell has a uniform thickness of 3·15 inches, relieved by six moulded ribs. The Renommée Hall at Liége is covered by three cupolas, each 55′ in diameter, placed at a height of 50′ above the ground. The cupolas are 4½ inches thick and are made of concrete composed of cement clinker finely broken; they are reinforced by a layer of expanded metal with a lattice work of bars.

A bridge, near Liége, 260 feet between abutments with a central span of 180 feet, 32·8 feet wide, was built upon a group of concrete piles driven deeply into the bed of gravel, which thus became strongly compressed. The concrete piles were reinforced by vertical bars of steel which were continued into the piers and abutments, so that the whole was solidly bound together and the bridge was solidly rooted into the earth. It had thus a resistance amply sufficient in case of an accumulation of ice which might transform the bridge into a dam.

W. E. WARRAND.

REVUE D'HISTOIRE.

July, 1905.

TWO MEMOIRS ON THE DRAGOONS, BY THE COMTE DE BELLE-ISLE.—Belle-isle was colonel-general of the French Dragoons, and these memoirs were written to call attention to their origin and true function as mounted infantry. One of his predecessors, Tassé, had done his best to turn them into cavalry, and the great increase in the number of regiments of dragoons had led to their being associated with cavalry on the wings in line of battle. But Belle-isle maintained that "dragoons are infinitely better and more sure of success when they are employed on foot than when they are mounted," and they should be handled accordingly.

THE CAMPAIGN OF 1793.—*Army of the North and of the Ardennes.*—The parts taken in the direction of the operations by the ministry, by the committee of public safety, and by the representatives on mission, are indicated; and it is shown how "the will to conquer" overcame the

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defects of the mechanism. On the side of the Allies, the division of interests and of aims is brought out. To the disgust of the *émigrés*, Condé and Valenciennes were taken over in the name of the Emperor Francis, not of Louis XVIII.; and similarly the Duke of York was instructed to take the surrender of Dunkirk in the name of George III. Dundas wrote: "It is just that by the progress of the campaign, we should participate in that indemnification which the belligerent Powers have ust reason to expect, and although the possession may be taken in the name of His Majesty, it does not exclude any future arrangements for putting that place in the possession of the Emperor if the events of the war should afford to His Majesty a sufficient indemnification in other quarters of the world."

THE WAR OF 1870–1871.—*The Army of Chalons.*—The fluctuations of opinion at Macmahon's headquarters between the 17th and 22nd August are described in detail. The evidence given at the Bazaine court-martial and at the inquiry into the acts of the Government of National Defence is supplemented from other sources, especially from the unpublished *Reminiscences of Marshal Macmahon.* In these he states that his decision on the 22nd to march from Reims on Montmédy, instead of falling back on Paris, was entirely due to Bazaine's message of the 19th, in which, after speaking of the battle of Gravelotte (the day before), Bazaine said that he still looked to marching northward and working round by Montmédy or Sedan. In a telegram of the 20th Bazaine hinted a doubt whether he could do this without compromising his army; but that message, though it reached Macmahon's headquarters, was not shown to the Marshal.

E. M. LLOYD.

TRANSPORT AND RAILROAD GAZETTE.

May 26th, 1905.

PROGRESS IN YARD DESIGN.—By W. C. Cushing (Pennsylvania R.R.).—(See also "Design and Operation of a Modern Freight Yard," by J. T. Richards, in the *Engineering Record* of April 29th, 1905, and sundry other recent papers).—American shunting yards are worked on three different systems:—(1) by push and pull (the ordinary familiar method); (2) by poling (where the engine runs on a road parallel to the train to be broken up); (3) by gravity (usually by pushing over a summit, and thence distributing by the cars' own weight. Gravitation pure and simple, such as is used in several places in this country, is not mentioned). The introduction of the hump, summit, or *dos d'âne*, as it may be variously called, as an expedient for the rapid distribution of trains, is comparatively modern, but it seems now to be embodied in all the more recent designs, and much thought has been expended on the lay-out of the yards. It is to be remarked that those under consideration are all what we should

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call "sorting and marshalling" sidings, as a "yard" proper generally appertains to a Goods depôt. Furthermore, the space occupied does not seem to be such a dominant factor as it often is over here.

The cardinal considerations to be borne in mind are :—the securing of an arrangement which will allow cars to pass through in the least possible time, continuous progress, and elimination of fouling movements whereby routes would conflict or Through trains interfere with shunting operations.

Where there are four tracks, of which the two middle lines are used for freight, the yard is generally placed in the centre ; but if the passenger tracks are in the middle, it may be necessary to elevate them, if there is likely to be much transfer between the Down and Up (or East and West bound) sidings.

The actual lay-out of the roads,—the ladder type of arrangement (*i.e.*, a straight distributing line from which the sorting roads branch off parallel) is usually adopted,—the siting of the lines for vans, for cripples and repairs, and the access for engines, are all of importance. As a rule the switches are controlled from a signal box in modern yards and moved by power, and the abolition of necessity for movement on foot by shunters is consistently aimed at. Of course one of the advantages of the "poling" system is that the men uncoupling remain with the engine and can travel on a platform provided thereon. Coupling up is automatic.

Some figures stated, of which I quote a few, give an idea of the magnitude of the traffic handled in some places. Incidentally I might remark that the Pennsylvania R.R. are reported to be reverting to smaller classes of cars for certain kinds of traffic, so as to secure quicker transit.

The Harrisburg yards have 109 miles of line and standing room for 10,000 cars (usually 40 ft. per car is allowed, and presumably connecting lines and turnouts are deducted in estimating capacity). They are worked partly by "hump" or gravitation, partly by "poling." 3,750 cars have been despatched Eastward in 72 trains, and 66 trains with 3,644 cars sent Westwards in 24 hours.

Altoona, another large yard, has a capacity of 10,000 cars. Here the average time taken in breaking up, *i.e.*, sorting, a train of 80 cars, is forty minutes (that is to say, cars of up to 50 tons capacity). 59 trains, of 2,915 cars in all, in one direction and 60 trains of 2,752 cars in the other have been handled in the 24 hours.

Mr. Cushing considers that no definite limit can be put to the size of Freight yards; but that the question really is "what is the limit of a Freight yard unit?" A unit may be taken as consisting of :—a receiving yard, a classification yard, a departure yard, and a proper number of car repair, van, van repair and engine roads. One set of these latter adjuncts may frequently serve two or more sets of receiving and classification tracks. (N.B.—No mention is made of how the trains are marshalled in station order, and it is not clear to what extent the arrangements aim at sorting for routes only, leaving Station distribution to be done on the road, or marshalling to be done away from the main centres). He thinks that twenty tracks is about as many as can be worked conveniently in one fan

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of sidings. It is of course important that where two units adjoin the movements should not conflict.

The gradients and resultant velocities attained in various yards have been calculated and are tabulated. On an average it appears that about 0·4 per cent. is sufficient to keep the cars moving, but over the turnouts and along the ladder tracks, the resistance being greater, a gradient of as much as 1·3 per cent. is sometimes used. At the neck a grade of about 3 per cent. for 100 ft. is necessary to give the vehicles a start, but this may be decreased if the descent is longer.

Weighbridges are often placed at the summit, in which case the gradient must be modified so that the speed shall not exceed three or four miles an hour, so that weighing can be accomplished.

Some particulars of working cost are given, but it would hardly be of interest to go into particulars.

While the study of these enormous yards may seem to us merely of academic interest, the same principles apply more or less to all sidings, and the diagrams, of which there are a number, deserve attentive study.

C. E. VICKERS.

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CORRESPONDENCE.

SUBMARINE MINING.

SIR,—An article by Colonel E. D. Malcolm, C.B., late R.E., in the August number of *Blackwood*, together with what I have heard elsewhere, seems to point conclusively to the fact that "Military Submarine Mining," as carried out for the last 30 years throughout the British Empire, is a thing of the past.

Whether or not, in some other shape or under some other name, it will rise again is a matter for speculation.

But I venture to suggest that it would be exceedingly interesting, and also instructive, if some account were given in the *R.E. Journal* of what has been done in this direction and what, so far, has been the result. In one point alone,—viz., the organization under which Regulars, Militia and Volunteers, not only of the United Kingdom but also of the Colonies, have worked together, each in their own way, to bring about the greatest economical efficiency—furnishes an object lesson that might well be taken to heart in other branches of the Service.

Pending the production of such an account, in my capacity as the last but one of the late dynasty of Inspectors-General of Fortifications, I should like to bear my testimony to the exceedingly efficient condition of Submarine Mining as I knew it in 1898 to 1903.

Naturally few officers outside the Corps of Royal Engineers knew much about it. But those who did, whatever branch of the Service they belonged to, not excluding the Royal Navy, were loud in its praises. On the outbreak of the late South African War the only Army organization at Home that was really prepared for war was that of Submarine Mining.

Yours truly,

RICHARD HARRISON,

General.

The Editor, "R.E. Journal."

THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

CHATHAM,

17th July, 1905.

SIR,—About 6 years ago a society was formed in America, called the American Railway Engineering and Maintenance of Way Association; and since its Proceedings should be of great value, I venture to bring it to the notice of those who are interested in railway matters.

The objects of the Association are "The advancement of knowledge pertaining to the scientific and economical location, construction.

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operation and maintenance of American railroads." The means being taken to attain this end are :—

(1). The investigation of matters pertaining to the objects of the Association by standing and special committees.

(2). Meetings for the discussion of papers and reports.

(3). The publication of papers, reports and discussions.

(4). The maintenance of a library.

There are 15 standing committees on :—

I. Roadway
II. Ballasting.
III. Ties.
IV. Rail.
V. Track.
VI. Buildings.
VII. Wooden bridges and trestles.
VIII. Masonry.
IX. Signs, fences, crossings and cattle-guards
X. Signalling and interlocking.
XI. Records, reports and accounts.
XII. Uniform rules, organization, code, etc.
XIII. Water service.
XIV. Yards and terminals.
XV. Iron and steel structures.

These committees are composed of 5 or 6 members, who are, as far as possible, selected from railways in different parts of the country, in order that the various views and practices in vogue may be discussed.

One of the first objects of the Association is to bring out a Manual of recommended Practice, as soon as the most desirable methods of carrying out work have been decided by the standing committees and discussed and approved at the general meeting. This should be a most useful book.

Membership is open practically to anybody who has had five years experience in any branch of railway engineering. The entrance fee is $10 (£2) and the annual subscription $10.

The Proceedings, which are bound annually, can be purchased, the price varying from $2 to $4. The first 5 volumes, bound in cloth, price $11 (£2 4s.). can be obtained from the Secretary, 1562, Monadnock Block, Chicago.

Except for a resident in the United States or Canada I see no advantage in becoming a member, as the Proceedings can be obtained for about one-third of the cost of membership. I ventured to point this out to the Secretary when in Chicago, and suggested a reduction in the subscription for a foreign member and also the alternative of a consolidated payment to avoid annual remittances. I hope this may yet be done, but even in America it takes over a year to alter the constitution of an association.

Yours truly,

E. BARNARDISTON,

The Editor, "R.E. Journal." *Capt., R.E.*

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RECENT PUBLICATIONS.

Report of the Royal Commission on Supply of Food and Raw Material in Time of War. Vol. I. The Report. (Fol. 1s. 8d. Wyman).

Report on the Engineer Operations of the Tibet Mission Escort, 1903–04. (Fol. Calcutta).

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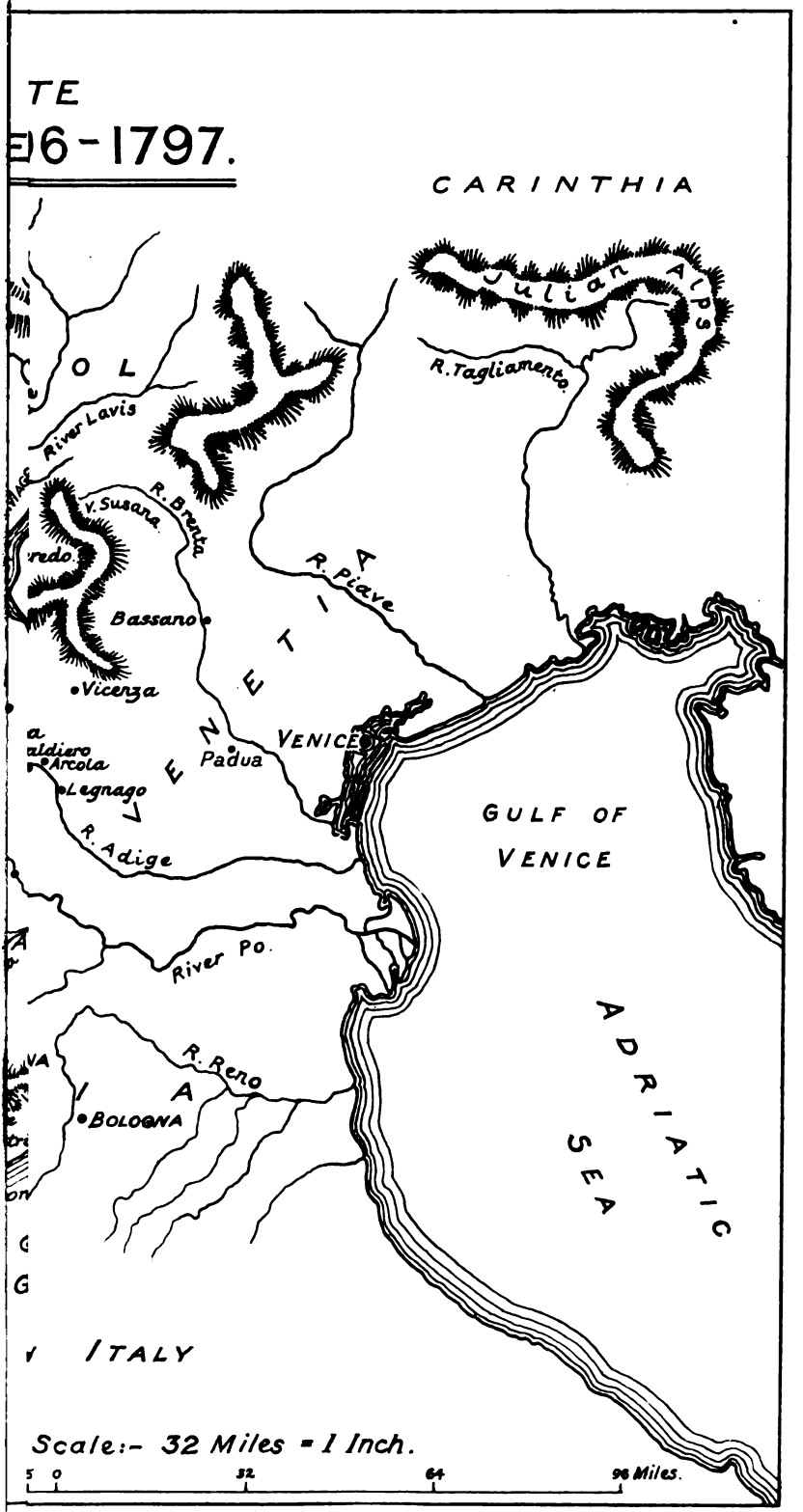

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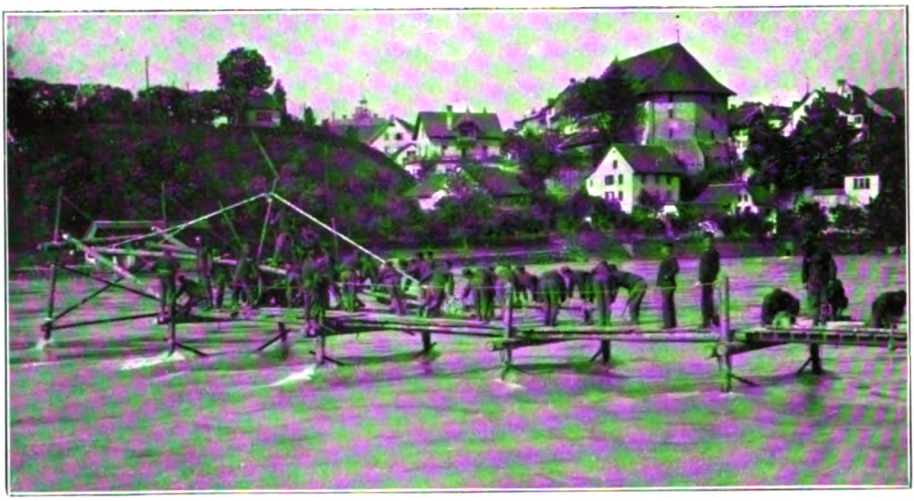

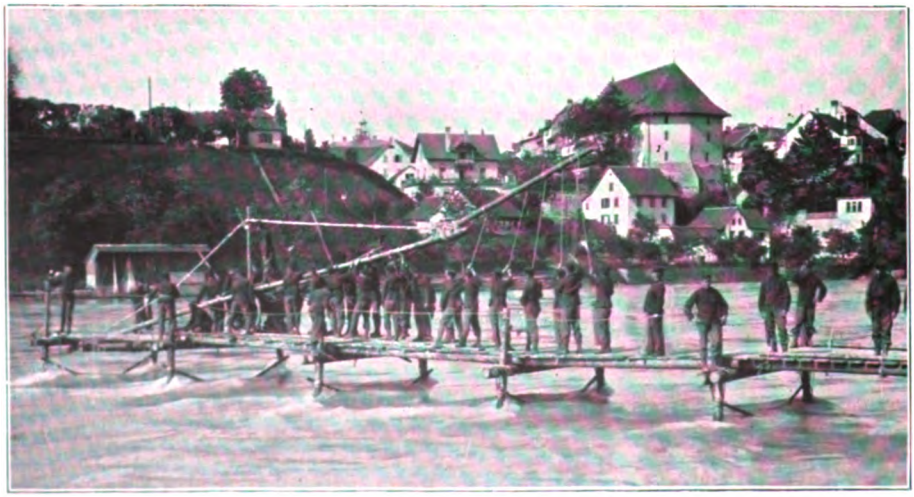

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THE PRINCIPLES OF ORGANISATION.

By Capt. J. W. S. Sewell, R.E.

In a recent article in the *R.E. Journal*, a writer called attention to the absence of any literature on the above subject. A great deal however has been written recently on what may be called applied organisation, that is to say organisation as applied to the Army generally or to some branch of the Army. Examinations cover a wide area, and entail an extensive knowledge of the details of this subject. It is moreover the fashion of the day, and doubtless has always been so, to criticise keenly such organisation.

But the principles of pure organisation, on which all applied organisation is or should be based, form no part of the curriculum of any Military School as far as I am aware. And yet these principles are as few, as simple, and as unchangeable as the fundamental laws of strategy. As with the laws of strategy, so the principles of organisation can only be violated with safety when exceptional factors enter into the personal equation. A few great leaders, knowing the personal defects of their opponents, have achieved victory by such violations of strategic principles as division of their force. In the same manner some great organisers achieve great results owing rather to their own personal genius and energy than to slavish adherence to fixed laws. Such cases are, however, the exceptions, and are only mentioned here in order that they may not be quoted as disproving the rules of pure organisation.

The subject is of great importance to the R.E. officer. It frequently occurs that he has to organise some undertaking *ab initio*. The officer who is zealous and energetic, and has good knowledge of detail but not of organisation, frequently starts off without efficient organisation and gets a long way by sheer personal effort. In war, with a short task and no time for organisation, this may sometimes be necessary, and is often very successful up to a certain point; but at the best a one-man concern is very risky. Under more normal circumstances the work has a knack of getting far beyond what the most energetic man can personally control in detail. An officer such as the above will probably find that his output *per caput* is diminishing; and, if he is to avoid chaos, he will have to inaugurate organisation, and produce order from confusion with a staff whose initiative he has successfully paralysed.

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The most recent work on pure organisation which I have been able to find in the Chatham library is a French translation of a German pamphlet, dated 1869 and entitled *De la Responsibilité dans la Guerre.* This pamphlet contains a recital of the causes which weakened initiative and responsibility in the armies of the period. These causes are of sufficient interest to reproduce in detail :—

1. Uniformity of tactics in the armies of the 18th century, composed of unreliable soldiers of fortune, foreigners who required iron discipline, brave but untrained officers, and superannuated generals and staff.

2. The idea that it was necessary to keep soldiers always occupied; hence refinement and exaggeration of uniformity and precision in manual and drill. Small minds excelled in this and acquired undeserved reputations; but it rendered the service dull, and checked progress and the promotion of better men.

3. The importance consequently attached to detail by all ranks of the military hierarchy.

4. Numerous (ceremonial) parades; and peace manœuvres worked out to prearranged schedules, regardless of the realities of war.

After the above enumeration the writer proceeds to give sundry precepts with a view to correcting the errors. These precepts form an amplification of the first Rule of Organisation, which may be stated as follows :—

Give to each subordinate a definite responsibility; cultivate his initiative; and do not allow him to shirk responsibility within his sphere of action.

The precepts referred to make the operation of this rule clear, and a brief summary of the principal points is therefore given.

1. Separate and define exactly the sphere of action of each individual.

2. Thus prevent a superior encroaching on the duties of a subordinate, that is doing his work or deciding points which lie in his sphere of duty. Superiors should not only avoid such action themselves, but should see that those under them are not encroaching on the duties of their subordinates.

3. Do not permit work to become mechanical: with this object demand little, but insist on that being good.

4. Deal severely both with the official who, through want of attention to regulations, steps outside his sphere, and with him who "refers for decision" of a superior any matters within his own sphere.

The second Rule of Organisation is a corollary of the first;—

Throw off detail on to subordinates.

To thus let go of detail is by no means easy. It requires self-restraint to judge by results without interference with methods; and still more self-restraint to avoid short-circuiting a subordinate and giving orders direct to his subordinates. In civil organisations this

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latter action would never be tolerated; but in military systems the sense of discipline makes it difficult for the subordinate to protest, and thus a bad habit has arisen. We all resent such interference by our own superiors, but are, most of us, somewhat prone to fall into this error ourselves.

But if initiative and responsibility are to be cultivated in our subordinates—if we are to be free to look around, to initiate, and to improve—interference in the sphere of action of our subordinates must be strenuously avoided. Our reward will come in the freedom gained from minor worries, enabling us, with full confidence in the ability of our subordinates, to attend to all current details, to take ourselves a wider and more comprehensive view, and to look ahead. I have heard the head of an important department, employing some 20,000 men and dealing with a turnover of nearly ten millions, complain that he had nothing to do: such men are organisers, who are not content simply to "carry on," but have always time to look ahead.

In the Army, most officers are provided with a "*fidus Achates*": the general has his staff officers, the battalion commander his adjutant, the captain his colour-sergeant, and so on. A good system of organisation may well result in peace time in reducing the work of these officials to a minimum. It will then be necessary to ensure that such assistants are not, in their desire to create work for themselves, regathering into their own hands the details which the superiors have intended to throw into the hands of subordinates. This is somewhat apt to be a weak point in military organisations; and the evil effects only become conspicuous in war, when such officials immediately become overworked, and the paralysis of initiative in subordinates becomes a heavy drag on the enterprise of the superior.

The third Rule of Organisation is:—

Limit the number of subordinates directly responsible to one superior.

With too many subordinates a superior will be tied to his office, and the result will be the same as in the case of a man who is hampered by detail. In considering this question in its application to the Army a most important object to be considered is the timely transmission of orders in the field. Prince Kraft, in his *Letters on Strategy*, says:—"The possibility of rapidly transmitting orders is one of the chief factors in deciding the number of divisions in a corps; and for this reason it is endeavoured to limit the number of subordinate authorities with which the corps headquarters have direct communication."

Though each organisation must be considered separately, and it is undesirable to be too precise when dealing with general principles, it may be suggested that, as a general rule, seven is a good maximum for the number of such subordinates: of these four may be heads of

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major departments, and three of minor ones. The minor departments have a way of increasing as new enterprises are undertaken, and it may then become necessary to group some of them under one head subordinate. This principle has been adopted in the new system of organisation of the Army Commands at home by grouping the administrative branches under a Major (or Brigadier) General in charge of Administration.

The organisation of our Field Army Commands shows the embodiment of these principles very clearly. They are so arranged that, with one curious exception, the officer in command has :—(A) four principal subordinates; and (B) a maximum of three minor departments or services, of less urgent consideration in the event of a collision with an opponent.

An Army Corps has :—(A) 3 divisions, corps troops.
(B) supply and transport, parks, and medical.

A Division :—(A) Cavalry, artillery, 2 infantry brigades.
(B) R.E., supply and transport, ambulance.

A Brigade :—(A) 4 battalions.
(B) Transport.

A Company :—(A) 4 sections.

The exception referred to is of course the battalion with 8 companies. Controversy still rages round this anachronism; in fact the problem was given as a subject for an essay in the last promotion examination. It is not proposed to discuss the matter here, but briefly it appears to be a question of sound organisation *versus* regimental tradition.

As an example of bad organisation and its evil results, that of the Austrian Army in the campaign of 1859 is notorious. The fatal results of the paralysis engendered by the detailed orders of the Commander-in-Chief are too well known to need further reference.

To write clear, concise, and (in war) frequently hurried orders is by no means easy; it may be remembered that Goethe once apologised for writing a long letter by saying that he had no time to write a short one. To render a proper system at all possible, it is obviously necessary that it should only be requisite to give orders to a few subordinates, and that these orders should leave to them all questions of method and detail. In a work on tactics in the Chatham library, I find, in an example of the orders of a General commanding an infantry brigade, a cavalry regiment, a battery, and a company R.E., such orders as;—"No firing is to take place without orders from commanders of units"; "Arrangements should be made for providing each man before starting with biscuits and hot coffee." Why should it be necessary to consider that the regimental officers are incompetent fools? Surely it is within the sphere of action of a commanding officer to take such steps as may be necessary to bring his men to the ordered point in good condition.

Such are the conditions to be borne in mind by an officer fortunate

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enough to be in a position to start organisation with a clean sheet. The question of the reform of army organisation is hardly germane to this article; but, inasmuch as one of the principal obstacles to be surmounted is the result of bad organisation in the past, it may not be amiss to refer to that unhealthy growth—the tendency to bureaucracy.

In war a number of officers are required for special duties, in excess of the real requirements of the army in peace. The necessity for finding employment for such officers in peace has, in the past, given rise to a system of administration in which such officers create work for themselves by redundant correspondence, refinements of check and audit, and interference with minute details, all tending to immense waste of labour, false economy, and passive resistance to progress. Without enlarging on this subject, I need only point to the extraordinary thirst for statistical information on the part of every administrative branch of the service; and to the intolerable delay in getting even a minor point settled, owing to the number of "post offices" which refer the question backwards, forwards, and sideways. The sister service is fortunately free from bureaucracy, and is correspondingly efficient.

An officer of the Egyptian army once told me that the "Babu" was scotched in that service by the fact that correspondence was conducted in Arabic, which most of the officers could not read. If a file showed signs of becoming too voluminous, it had a way of being "lost" out of a railway carriage window. Whilst not interpreting this narrative too literally, it has sometimes occurred to me that the introduction of Chinese as the medium of official correspondence would not be without certain advantages.

The modern tendency is to improve this bureaucracy out of the service, and undoubtedly great strides have been made of late years. But such reform can only be gradual; the task is Herculean; and to clear this mass of inertia out of the way is an undertaking that may well break the heart of an army reformer.

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*OVER-SEA EXPEDITIONS.**

By Bt.-Colonel T. Capper, *p.s.c.*, d.s.o., d.a.a.g. Staff College.

It is impossible to go into all the details of the subject in a short lecture of this description. I propose therefore to give one instance† of a large force landing in the teeth of opposition from a civilised, and equally well-armed and disciplined, foe; and then to point out what a difference steam and modern armaments have made in this respect.

I will deal first with the landing of our troops in Aboukir Bay, in 1801. The French expedition to Egypt, which Napoleon hoped would be his first step towards the founding of a huge Oriental dependency to France, had met with a severe check. The gallant defence of Acre by Sir Sidney Smith had upset all his plans. Egypt right up to Philae (Assouan), where the names of his officers may still be seen carved on the walls of the ruined temples, was fully in his power; but the French forces, bounded on either side by deserts, could achieve nothing more. Furthermore the battle of the Nile, Nelson's famous victory in 1798, had given England command of the Mediterranean Sea.

Napoleon had reconciled it with his conscience to desert his army in Egypt and had returned to France, leaving General Menou (after the assassination of General Kleber) in command of the French army. There was no question of the army itself going back to France, for there were no ships. There was little opportunity of it invading India, as was its original intention; no ships were allowed to leave French ports in the East for any such purpose. Surrounded by hostile Arab tribes, and with a Turkish army assembling in Syria, there was no chance of an escape *viâ* the east coast of the Levant. Nevertheless the British Government deemed the presence of a French force of between 12,000 and 15,000 men in Egypt a menace to our Indian possessions.

* Shorthand report of Lecture delivered at the Royal Engineers Institute on 16th March, 1905.

† The main features of the principal over-sea expeditions since 1850 are recorded in the essay on *The best method for carrying out the Conjoint practice of the Navy and Army in embarkation and disembarkation, illustrated by the experience of the past*, which was awarded the Gold Medal of the Royal United Service Institution for 1904 and published in the April, 1905, number of its *Journal*.—Ed.

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There was at this time at Gibraltar a British military expeditionary force. It was a picked force, and consisted of the flower of the British army. Its *rôle* was to act as required, using Gibraltar as a jumping off place.

This force made several false starts. It first attempted an attack on the harbour of Ferrol, near Corunna on the north-west point of Spain, where at the time lay six Spanish men-of-war. The landing was successful; but the General in command, being alarmed at the strength of the Spanish defences and the news he heard of the force the enemy were bringing up, re-embarked on his transports and returned to Gibraltar. Two months later the force attempted to attack Cadiz, but here again indecision and feebleness of command prevented success.

People now began to ask of what use was this splendid force, kept at Gibraltar; why continue the expense of its upkeep when it did nothing? Expeditions to Italy and to Spanish America were discussed. These very diverse objectives show us how wide the field of employment may be which lies before an expeditionary force having free use of the sea and situated in some central position; and the conditions will no doubt repeat themselves some time or the other in the future.

Under the then existing circumstances the Government decided on a descent on Egypt. The command of the Mediterranean was, by Nelson's splendid victory of the Nile in 1798, indisputably in the hands of the British. French despatch vessels could only with difficulty get in and out of Alexandria. A comprehensive plan was formed.

The special service force, amounting to 12,000 men, was to be despatched from Gibraltar under Sir Ralph Abercrombie, who had previous experience of this sort of work. The idea was that this force should proceed to Asia Minor, and there arrange for co-operation with the Turkish forces in Syria against the French in Egypt. Meanwhile an expedition was to be despatched from India to invade Egypt from the Red Sea side. That was the general plan of the campaign. We will see how it worked out.

The time of year was most unfavourable. The orders for the expedition were received at Gibraltar on the 25th October, 1800. Everyone knows that the Mediterranean is liable to severe storms in the winter; and to manage a large fleet of transports and battleships, all dependent on sails, in bad weather was a severe task. Nevertheless there was no hesitation in starting. All ranks were feeling the effect of their inaction and previous feeble attempts, and Sir Ralph Abercrombie was determined to satisfy their legitimate aspirations to show what they could really do. Like Sir John Jervis before the battle of St. Vincent, he felt that the country badly wanted a victory.

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Malta was made the first rendezvous; and here the troops were partially disembarked and the vessels thoroughly put into good order. The next point made for was Marmorice Bay in Asia Minor, not far from Rhodes and about 150 miles in a straight line from Alexandria. To Marmorice Bay the expedition proceeded in two portions, and after a very rough voyage was finally established in the harbour by the 11th of January, 1901.

The Turks had promised material assistance in gunboats, cavalry horses, and troops; and a great deal of importance was attached also to the moral advantage to be derived from their support. The Turks are of the same religion as the majority of Egyptians; it was therefore fair to expect that the Egyptians would gladly side with the Allies against the French invaders. As results turned out the material assistance derived from the Turks was practically *nil*. They showed the worst traits of an Oriental nation. Even the horses they had promised were so poor that only 200 for the cavalry and 50 for the artillery could be utilised.

Nevertheless the delay at Marmorice Bay was profitably employed. The sick were landed and encamped; the ships were thoroughly overhauled and cleaned; and above all, the troops were constantly practised in the method of disembarking from the ships to the shore. This matter of practice was perhaps the secret of the ultimate success of the expedition. Marmorice Bay itself was a most suitable place for such practice; the water was calm, and there was plenty of room.

However it soon became evident to Sir Ralph Abercrombie that the Turks were absolutely useless. Their army, assembled at Jaffa, was found on inspection by General (afterwards Sir John) Moore to be incapable of action through sickness and lack of discipline. The Turkish gunboats, always faithfully promised, never turned up.

Meanwhile Sir Ralph Abercrombie became anxious. It was always possible that the French would get to know of the Turkish impotence and march to destroy them. It must also be recollected that communication with India was difficult, and the exact co-operation of the Indian expedition, or indeed even news of it, could not be depended on; there were no such things as telegraphs or quick despatch steamers by which news could be obtained. Sir R. Abercrombie's position was difficult; there was no information about Egypt at all, except what Sir S. Smith could give from his own experience which did not embrace the interior; there were no maps, and the best that could be made out and distributed to the Generals was most inaccurate; there was also no really exact information as to the French strength. Added to all this the time of year was most unfavourable; the Equinox was approaching, and the weather was consistently bad. Nevertheless, in spite of all the difficulties, the British commander determined to carry out the enterprise single handed.

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The local pilots declared a landing on the Egyptian coast impossible until the stormy season was over; but on the 25th of February the expedition left Marmorice Bay in 175 vessels. The effective British force in the field can be reckoned at 12,000; it was formed into six infantry brigades, one cavalry brigade of two regiments, and an infantry reserve division under General Moore. The voyage was accomplished in fair order, notwithstanding the weather; but one mule ship foundered and some of the other smaller vessels, carrying mostly animals, got separated; this caused great anxiety least all the horses and transport animals should be lost. Two Royal Engineer officers, sent in to reconnoitre the coast, unfortunately fell into the hands of the French in Aboukir Bay, one being killed and the other taken prisoner. Furthermore a French vessel, which had by mistake fallen in with the British flotilla in the night, sailed in the company of the British vessels for some days, wisely hoisting the English flag and answering all the signals made; she kept her identity quite secret till near Alexandria, where she eventually arrived with news as to the approaching expedition.

The British expedition arrived at Aboukir Bay on the 3rd of March, but the weather was so bad that no landing could be attempted till after the 7th. These circumstances combined to give the French ample notice of the intended invasion, of which they were not slow to take advantage.

One may ask, why did not the expedition change its point of attack, since all chance of surprise was over? It was very much a question of Hobson's choice; there was no other suitable place; by reason of the surf on the north shore it was impossible to land there. Moreover it must not be supposed that Aboukir itself was the sole objective; it was intended to take Alexandria, and so secure a sea base of operations for further operations in Egypt. Aboukir was a sheltered harbour; and on the northern side of the coast, between it and Alexandria, there was deep water so close in shore that vessels could work alongside the troops and keep them supplied with the necessary provisions, especially with water. Furthermore the place itself was one well calculated to inspire an Englishman with a high spirit. It was the actual site of the battle of the Nile. In that action the French fleet had been destroyed as nearly as possible on the five-fathom line of Aboukir Bay. On this occasion the British fleet took up exactly the same position as the French fleet in 1798; and one of our men-of-war, the *Foudroyant*, actually chafed her cables against the wreck of the *L'Orient*, and later on fished up her anchors. One can imagine what thoughts filled the British troops at the idea of another conflict with the French on this historic ground, and how our army must have determined that if the navy had a victory of the Nile the army must have one also.

On the 7th of March, as the weather had somewhat moderated

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and the surf to some degree subsided, the Admiral and General went in a boat to examine the shore by personal inspection. At the same time Sir Sidney Smith was sent with three armed launches to endeavour to get information. This little party landed at the entrance to the Lake of Aboukir (Lake Maadie), and drove off a party of 50 of the enemy who held a blockhouse; but as observers on the ships could see a large number of French moving down to attack the party, it was recalled to the ships. They brought away the ferryman at the point, but he could give no information. It was, however, clear that the French had made full use of their opportunity of organising a resistance, and it became known that they would oppose the landing with at least 2,000 men and 15 field guns, all under excellent cover behind the sand hills which abound on the beach. The appearance of the beach from the sea shows a succession of these sand hills, rising at times to a height of 180 feet and interspersed with a few date palms. The French further had the service of 10 guns and 2 mortars in Aboukir fort.

On the other hand the English men-of-war could not approach close enough to assist the landing to any material extent with their fire. It should be observed that the five-fathom line is about two miles from the shore at this place. Small vessels, such as gunboats, could stand in close; but the assistance of the broadsides of the battleships was denied. There was not sufficient boat accommodation for the whole force to land at once; so it was decided that the first landing party should consist of the Reserve Division under Major-General Moore, the Brigade of Guards, a portion of the 1st Brigade under Major-General Coote, and 1,000 seamen under Sir Sidney Smith to drag the guns up the hills. This force (numbering about 5,500 with 10 guns) was put into about 150 boats; the remaining men of the 1st and 2nd Brigades were placed in light-draught ships to stand as close in shore as possible and act as a support, with the idea of being landed by the boats as soon after the first party as could be managed, by which means the second trip of the boats would be reduced in length.

At 2 a.m. on the 8th of March the troops destined to form the landing party entered their boats. At 3 a.m. a signal was made for all boats to proceed to the rendezvous, a light-draught vessel anchored in front of the fleet about gunshot from the shore. Seaward of this vessel the boats were to form up in three lines; the first consisting of launches and flat-bottomed boats containing the infantry and artillery; the second of all the ships' cutters which were to give assistance to the first line on landing; and the third of ships' cutters and boats in tow. One can imagine the difficulty of accurately deploying a boat flotilla of this size, and the operation of lining up was not completed until 9 a.m. The flanks of the boats were protected by armed gunboats; two bomb vessels were placed to cover

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the landing with their fire; three other vessels were moored with their broadsides to the shore for the same purpose, but the water was so shallow that none of these could render material assistance.

The undertaking was an imposing one, and the risk of failure extreme. There was no question of elaborate tactics: it was just a frontal attack, imperfectly supported by artillery, against a vigilant enemy in a prepared position. The French, formed up in a semi-circle, well covered, and with their left flank resting on a fort, could not believe the English were really mad enough to attempt to force a landing at this point. But it must not be supposed that the latter were acting recklessly, or in any but a properly thought-out and cool manner. As I have said, if they wanted Alexandria they had but one point where they could effect a satisfactory landing. The risk was thoroughly realised, and elaborate and careful preparations were made. There was no question of seeing red and charging a strong position in a reckless, bull-headed fashion. The Admiral in command of the fleet had, while at Marmorice, issued most elaborate instructions to his officers. So early as the 24th of January, six weeks before the actual operation, general principles were settled and circulated, and the orders in general terms of both the Admiral and General issued. In this we have distinct evidence of the value of the practice obtained at previous landings.

There is one point which is interesting. The formation was that of companies in company column. The second and third lines of boats contained men of the same company as the first line, so that when the boats of the first line took the shore they were supported by other boats containing men of the same companies. I should think the conditions are so different now that this plan could hardly be carried out. It was intended that the second and third line boats should run up between the first line flats, which were to take the shore at about 50 feet intervals; the flats hauling off clear, as soon as they had discharged their load, by means of stern grapnels. The boats were in four divisions, each under a Naval Captain.

At 9 a.m. the signal was given for the boats to advance. They at once pulled for the shore, keeping a very good line. Directly on arriving within range they were met by a tremendous artillery fire, both from Fort Aboukir and from the batteries of artillery on shore. Very little harm was done; three boats were sunk, but the cutters in the second line brought assistance without checking the onward movement. When it came to the musketry stage the British began to suffer heavy loss; but there was nothing to be done except to keep on rowing as hard as they could, and the boats reached the shore in very good order. The first regiments to touch land (the 23rd and 40th) formed up rapidly, and their flank companies, without firing a shot, charged the enemy's position at the point of the bayonet and drove off a half-brigade, capturing three guns. The 28th and

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42nd regiments attacked in front and repulsed the charge of 200 French dragoons. The next troops ashore were the Guards; they were also charged by the same cavalry but, supported by the 50th regiment, drove them off; a French counterstroke by 600 men against the left of the Guards was met by the 54th regiment and also repulsed. The actual fighting in the attack lasted about twenty minutes. After a desultory combat in the sand hills for another hour and a-half the French were fairly beaten, with the loss of 400 men, 8 guns, and many horses. The British loss was about 750 killed and wounded. The next day the British marched four miles to the westward, masking the fort of Aboukir with one battalion and a regiment of dismounted dragoons.

It has been suggested that the attack and the landing could have been more scientifically conducted; that the blockhouse captured on the 7th should have been held, and a flotilla of gunboats passed through the Lake of Aboukir to turn the French right while they were occupied with a frontal attack, very much in the same way as the Japanese gunboats assisted the other day in carrying the strong Russian position at Nanshan. Sir Sidney Smith recommended this course from his knowledge of the ground and water; and though it certainly seems to us to have been a good plan, we must not suffer ourselves to detract from the courage and resolution of the Commanders, who were determined to force a landing. I am sorry that I can find no detail of the actual landing of the stores, nor of the land transport; but I gather that the army landed necessaries only, and kept itself supplied from the fleet which advanced parallel with it. The service of supply was very difficult by reason of the surf, and over 100 lives were lost, in accidents in the surf and in the landings, before the occupation of Alexandria.

We can now consider how far steam affects the question of landings. Steam allows vessels to proceed much quicker than they could when they had to rely on sails. On the other hand most countries have railways, on which steam enables troops to be assembled at given points with great rapidity. These changes, together with modern artillery and rifles, enormously increase the difficulties of an expedition such as I have described. Supposing the boats have been formed up at a spot far out at sea, they are subject to artillery fire the moment they leave the protection of the men-of-war; and when they get closer in, say within a distance of 2,000 or 1,500 yards, they come within range of machine guns and rifles; thus they stand a poor chance of ever reaching the shore.

It is easy to see how the difficulties are greatly enhanced; but there is no doubt that we shall again have to undertake expeditions of this sort in the future, and, as every Englishman of course hopes that if fighting is to take place it will be across the sea and not at home, it is important that we should pay attention to such operations.

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One can imagine some of the objects we might have to undertake. We might have to seize a Colonial possession ; or we might have to take a harbour containing the enemy's fleet, and establish a base for moving inland. The objectives of expeditions of this sort are well known to the Intelligence Department, and the matter of details is not neglected.

The sort of *modus operandi* in carrying them out would be this. The main objective would be settled by the Ministry, and the Naval and Military Executive Commanders would be admitted to their counsels. The main objective having been decided on, it would rest with the Naval and Military Executive Commanders to work out the details—the force to be employed, the taking up of the transports, the embarkation, the rendezvous of the expedition (some suitable harbour or protected water), the voyage, the landing on the coast—all these things are of the greatest importance. During peace time, too, naval and military officers are engaged in finding out all particulars as to the places where troops might require to land. It is absolutely necessary that all the above should be known beforehand. It is also necessary that the Navy and Army should co-operate together in working out the details. For instance, in the chartering of transports the Navy would say they could take so many thousands troops ; the Army would want a voice in the allotment of the troops to those transports, because they would require the commands to be kept intact as far as possible and the troops arranged in the most convenient manner with a view to landing. In the landing itself also it is essential that the two services should work together.

The principle to be kept carefully in view in working out an expedition of this kind is to first settle the objective and the tactical method by which the troops, assisted by the fleet, will attain it ; and from this work out the details of the fitting out and embarking of the expedition. All details of the landing and tactical employment of the troops must be clearly arranged before those of transports and embarkation are worked out. It is wrong to settle the embarkation first and the landing afterwards.

(The lecturer then illustrated by means of a number of photographic views the disembarking and re-embarking operations at Clacton in the Essex manœuvres of last year. The transports used were described, as well as the means adopted for lowering the horses, wagons, and guns into the boats for conveyance to shore. It is now intended to introduce a special steel float of a larger type than the boat hitherto used, which takes ten horses, or two large transport wagons, or four or six two-wheeled vehicles. A great deal of trouble was caused when the wagons were not properly loaded and their contents well pressed down; they were then top heavy; on one occasion a boat containing two wagons capsized in deep water, from which the wagons could not be recovered. New rules are to be introduced that the top of the load on any vehicle must not be more than 8½ ft. from the ground).

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TRAINING OF FIELD COMPANIES, R.E.

By MAJOR R. U. H. BUCKLAND, R.E.

THE following remarks apply only to the men of the Field Companies. From what I have seen of the work of the Bridging and Telegraph units I think that the hand of the reformer had better leave them severely alone; first-rate at their own jobs, they are always ready to help others; I have seen the old "A" Pontoon Troop employed in fitting up an extensive hut hospital, and men of the Telegraphs assisting to erect the wire fences of a remount establishment.

What is required of a Field Company on service?

We all know the long list in which are enumerated the various kinds of work that may fall to our lot in the field. But in what shape does any job present itself to the men?

We may assume that, under normal conditions, to judge of the necessity or otherwise of any particular piece of work is outside the province of the rank and file. The O.C. of the Company is told that a certain piece of work is to be done; he tells a subaltern to see what is required, to visit the site if necessary, and get the work carried out.

The subaltern roughs out in his mind's eye, or still better on paper, a "project," with a list of material and tools necessary. If wise, he consults his senior N.C.O. to see whether he has forgotten anything. He then selects from his section the men whose *trades* are most suited to the work contemplated. The result is that on most days whilst on service the sapper is employed at his trade, or at some kindred trade where his technical skill tends to facilitate the accomplishment of the work in hand.

The sapper's training at his trade is therefore a matter of the highest importance, and the modern tendency to take the men away from their trades must result in lowering the standard of technical skill. To this point I will revert later.

Turning to the table given on the first page of Capt. Craster's excellent article in the July number of the *R.E. Journal*, and excepting Ballooning as being a special branch, it is to be noted that a sapper recruit, whatever his trade may be, has to receive instruction in:—(I.) Field fortification, (II.) Siege works, (III.) Bridging, (IV.) Hutting, (V.) Water supply, (VI.) Roads, (VII.) Railways, (VIII.) Telephones—a fairly comprehensive list.

The question is what standard of knowledge in each subject is to be

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expected of (*a*) The trained recruit, (*b*) N.C.O.s of each rank; and how is the recruit to be instructed so that he may reach this standard.

(A). Taking first the case of the recruit:—

(I.). *Field Fortification.*—The only dimensions which a recruit need be made to learn are those which represent the penetration of the latest model of rifle into all classes of material. This can be taught him by letting him see bullets go through a parapet or shield of insufficient thickness and mark an iron target behind it. He must be continually questioned on this subject, and shown that the penetration of the enemy's bullet is the ruling factor in all hasty field defences. A trained sapper who cannot at any moment quote the penetration of rifle bullets should at once be placed on the lower rate of Service Pay—he is useless.

Having learnt that earth is a protection against bullets, the recruit must next be shown, on all sorts of ground, where an infantry firing line is most likely to be placed *in connection with some tactical idea;* and when he has quite grasped this idea, he must be allowed to dig at his own sweet will till he can in that firing line protect himself from hostile bullets, and still be able to fire with suitable elevation at certain objects pointed out to him beforehand.

His first efforts may be ungainly; they will vary according to the intelligence of the individual; but some sort of hole will be dug, and some sort of mound of earth will spring up. The best instructors will at this period interfere the least; they will merely ask the recruit whether the earth is thick enough to protect him, and whether he can see to fire at the objects pointed out to him. (Of course all field-work instruction must be done under arms). Something having been accomplished the recruit will be shown how, if time allows, his firing position may be made more secure by better protection for his head; and out of such material as may be at hand he will be taught to make a loophole. At the same time the necessity for concealment must be impressed upon him.

The next steps in advance are the connection of these various holes into short trenches, with means of entrance and egress and drainage.

On all occasions, before any digging is commenced, each man must know the tactical idea and what he himself has to fire at. If, when his trench is completed, he cannot show that he can aim his rifle with correct elevation at the prescribed objects, his labour in digging is wasted.

The further development of overhead cover from shrapnel, and all such elaborations, will follow easily enough, if once the fire trench is correctly sited and made.

The idea of the above suggested system is to subordinate the digging of the trench to the tactical conditions which obtain on the spot. The site of the trench is infinitely more important than the amount of protection it affords.

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It is essential that the recruit should produce something himself and be then shown how it can be improved; to show him a model trench with model loop-holes and tell him to copy it is to begin at the wrong end. It causes him to expend all his thought on copying the model with exactness, instead of evolving protection suited to the scheme on which he is engaged.

The old system used to be to make a perfectly straight trench, with beautiful slopes and a carefully patted parapet, the blue-frock-coated instructor running about all the time with a 6-foot rod and a field level.

The making of hurdles, gabions, and fascines is an important branch of the recruit's training, and leads on to (IV.) hutting,—the more finished class of huts being the work of men of building trades, and not fieldworks in the ordinary sense.

The use of the field level should not be taught in connection with fire trenches; but it is necessary for the laying out of batteries (II.) and comes in again in roads (VI.).

(III.). *Bridging.*—Individual knowledge of knotting and lashing is indispensable, and ignorance of any knot in the *Manual of Military Engineering* should cause a trained sapper at any time to be reduced to the lower class of Service Pay.

Recruits need do nothing more elaborate than trestle, single-lock, and double-lock bridges and barrel-pier rafts, but they should go through a prolonged course of pontooning.

If instruction in pontooning is carried out properly the men get the benefit of the drill, that is to say they work quickly and energetically at the word of command, whilst the heavy weights exercise all their muscles. The further lesson of everything being always in its place, so necessary for night work, is not without its value. Pontooning is at the same time a most useful training in responsibility for the junior N.C.O. instructors, and teaches that "ganging" of men which is the secret of carrying out work on any large scale. A man who can warp a raft satisfactorily on the Medway, when the wind is high and blowing against a strong flood tide, will be a useful man at any job. A short course of pontooning is of little value, it is forgotten as soon as learnt. Landing stages, fixed and floating, afford a useful variety in the instruction, whereas bridging on a large scale over spans of 50 feet and upwards should be left to the Field Companies at their annual training.

(V.). *Water Supply.*—As regards the rank and file this is to a large extent a question of carpenters' and plumbers' work; once men have been in camp they know what sort of thing is required, and can carry out intelligently their officer's orders on the subject.

(VI.). *Roads.*—As far as the rank and file are concerned this is a question of laying out directions and slopes with a field level and putting in culverts, the latter being work for the bricklayers and masons.

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(VII.). *Railways.*—It is rather for the R.E. railway experts to say what amount of assistance they count on receiving from the Field Companies; but whatever they require must be taught thoroughly, and be kept up every year in the annual training. This standard should be clearly laid down; probably it need not be a very high one.

(VIII.). *Telephones.*—The usefulness of telephones on the outpost line seems as yet hardly appreciated in our service. If there is to be in future a Field Company with each brigade, the Brigadier should be able to count on at least 10 miles of telephone cable with an exchange and (say) 10 instruments being available whenever required. All ranks must be taught to make joints, lay out a roll of cable, and make up batteries, but instrument repairers will be required in much greater numbers than exist at present.

(B). To review the same subjects with reference to the standard of knowledge to be expected from N.C.O.s :—

The standard must be clearly laid down for each rank, and men falling short of the prescribed standard should not be promoted. Only when they see how it affects their promotion will men take care to keep themselves up to the mark in fieldworks.

The following is a rough outline of the standard I would suggest.

In (I.) a Lance-Corporal must be able :—

To show on a selected easy piece of ground, by means of a tape, the line of an infantry fire trench to fulfil the conditions of a given tactical idea; to say how long the task would take the infantry, and what elaborations could be carried out simultaneously if a given number of R.E. were available; and to give a list of tools and material he would want were he in command of the sappers.

2nd Corporals and Corporals, as above; but the questions would be made more difficult, proportionately to rank, by selecting less easy ground, and communications would have to be provided for.

A Sergeant should be capable of arranging the defence of a farm or homestead and a certain extent of open ground on either side. Given a section of R.E. with their tools (which he must know), and a fixed number of infantry allotted to the defence of this section, he must evolve on paper the best that can be done in the number of hours available; he must clearly show where all the material on which he counts is to be found. The compass bearing of probable lines of attack should be given him, but probable hostile artillery positions he must notice for himself.

In (II.) a Lance-Corporal must be able to trace siege works at night, and estimate working parties, tools, and material for simple works.

More difficult works for the higher ranks.

In (III.) a Lance-Corporal must be able to show on a sketch the means of bridging small gaps with given material, estimating working parties, tools, material, and time required.

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For higher ranks more difficult questions would be set, including landing stages with derricks over water and temporary platforms at railway stations. A Sergeant should be capable of bridging any gap up to 40 feet, showing in addition where his material is to come from.

It is not worth following the question of fieldwork instruction any further, but I would again insist on simplicity of instruction for recruits, and the necessity for all ranks to show qualifications up to a high standard before being considered eligible for promotion.

The standard of knowledge which it is intended that recruits should reach must be clearly laid down and known throughout the Corps. A batch of recruits joining a Field Company would be at once tested as to their knowledge of fieldworks, and if any fell short of the standard the matter would be at once reported through the Divisional General to the Commandant, S.M.E. Only in this way can the Instructor in Fieldworks at the S.M.E. know to what extent his staff are successful in imparting instruction.

The next point is the annual training of the Field Company, which may be considered to begin on 1st April.

To work Royal Engineers in large numbers together is to invent conditions which do not frequently obtain in war. To my mind an R.E. Company *as a whole* digging a fire trench is pure waste of intelligent skill. As a rule R.E. will best be used in assisting infantry; therefore their training in peace time must be with infantry.

Infantry commence their company training on 1st April. G.O.C.s of Divisions might well call upon the officers commanding Field Companies to put at the disposal of each battalion commander a certain number of their N.C.O.s and men (the number will of course vary according to the number of battalions in the command), the R.E. being sent to live with the battalion to which they are allotted if it is at an out station. Each infantry company will do about 10 days fieldworks during its 6 weeks' training, and with a little arrangement the O.C. Field Company will be able to ensure that all his men get their share of this most useful practice of working with infantry under infantry officers. The R.E. company officers should see their men at work without in any way interfering with the instruction given by the infantry officers, but the O.C. of the Field Company will have an opportunity of making observations on this instruction when submitting his report on the annual training of his company.

After the infantry training is over the company can go on with its training in subjects in which on service it will work either unassisted or assisted by only small parties of infantry. The best practice for the company is to work with a minimum of R.E. assisted by other corps. In a case that came under my knowledge the men of a field battery came and helped a weak half-company of R.E. to make a trestle bridge on rather an awkward site; the battery afterwards

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took their guns over it, fully horsed, the R.E. subaltern in charge having been made responsible that the bridge stood the test.

All ranks of all branches are wonderfully keen now-a-days on any genuine work with as little as possible make-believe about it, and with the assistance of the Divisional General and his Brigadiers it ought not to be difficult to work out small schemes for training in combination with other arms.

Certain subjects, such as sapping, mining, demolitions, and pontooning, are for R.E. only ; but in almost all other forms of bridging, and in using rafts and landing stages, all arms can help, and can gain useful experience for themselves.

The old hard and fast annual "fieldwork course" of the company must now give way to a "scheme of training" in which we can work with other troops as on service. This training and the work in connection with camps of instruction will keep the Field Company employed from 1st April to the end of August, and the musketry course will account for another 10 days or so.

Semaphore signalling, range finding, and other such necessary subjects, must be taught in the mornings before breakfast from 1st April onwards until the necessary degree of proficiency is obtained, and occasional practice at other times will be necessary to ensure that the instruction is not forgotten.

As soon as the Divisional General has done with the company and the musketry is over, the O.C. can turn his attention to the important matter of the technical skill of his men.

Good tradesmen will not enlist if they see no chance of improving their technical skill whilst serving ; skill at fieldworks is of no use to a sapper seeking for employment on return to civil life !

The best training is steady employment in workshops, and the best test of skill is the moneying out of the value of the work done. Such men as plumbers, bricklayers, and masons cannot as a rule work in a shop ; but their work can always be measured and moneyed out, and this supervision is the province of the subalterns, who will thereby get most useful experience as to the cost of work and the time it takes. If the C.R.E. can be induced to hand over some small items of his Barrack Annual Estimate to the O.C. Field Company to carry out, the instruction thereby afforded is excellent ; but the difficulty is that, when apportioning his work for the year, the C.R.E. probably does not know for how long the company will be working for him, and if their outdoor work is stopped by frost during the winter months, he may be left with unfinished work on his hands at the end of the financial year.

The difficulty could best be overcome by the Divisional General fixing early in the year a certain period during which the company would be available for the C.R.E.'s work ; and during this period all military considerations, such as field days and ceremonial drill, must

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cease as far as the dismounted men are concerned. Route marching is a waste of the sappers' time ; but the officers of the company and the mounted sections should always go out with their brigades or divisions to represent a skeleton company, so that other troops may be accustomed to their presence, and the Generals and their staffs learn to include them in their orders and to make use of them.

The only interruption to the work period is the furlough season. This will cause the least possible loss of efficiency if it is arranged that all the sappers entitled to, and wishing to take, furlough should go away at the end of the week before Christmas ; so that during this period the works, as far as the company is concerned, would be shut down. For the mounted men this arrangement is not possible, as the horses must be fed and exercised ; they must go away a few at a time throughout the furlough season.

The question of organization for war of the R.E. Regular units, and the full utilization of the R.E. Militia and Volunteers, is a fascinating one, but this paper is limited to the training of the men of R.E. Field Companies.

My only excuse for writing at such length is that the training of our men must always be a subject of the greatest interest to the officers who serve with them. The comfortable feeling of the commander of any R.E. unit in the field when the strain of work is exceedingly heavy, the weather vile, and circumstances conspire to upset all arrangements for transport, rations, etc.—the certain knowledge that *somehow* the men will get the day's work done, and be ready to go at it again on the morrow—makes days of toil and discomfort days on which one can look back with pleasure.

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THE CONSTRUCTION OF THE NATHU LA ROAD, TIBET MISSION, 1904.

By CAPT. R. ST. J. GILLESPIE, R.E.

THE Nathu La is a pass over the range of mountains which divides the State of Sikkim from the Chumbi Valley in Tibet. The construction of the road was undertaken in connection with the Tibet Mission in 1904, with the object of providing a road from Sikkim to the Chumbi Valley which would be practicable for pack transport and, at a pinch, for *ekkas**; at the same time the possibility was to be kept in sight that it might be necessary at some time to man-handle field guns over the road.

The only route into Tibet which was reasonably practicable for animals was that over the pass known as the Jelap La. This was very steep and liable to interruption by slips, and was not considered capable of sufficient improvement.

Orders were issued by the General Officer Commanding on the 12th June, the day on which the first part of the Lhasa Column left Chumbi, for the construction over the Nathu La of an 8-foot road on a maximum grade of 1 in 15.

The staff originally detailed for the work consisted of one Field Engineer, Capt. R. St. J. Gillespie, R.E., two sergeants from the Military Works, and four sub-overseers and a small office establishment from the Public Works. At the time of commencing work, a rough path existed from Gantok, the capital of Sikkim, to the Chumbi Valley. This was originally a trade route; but it was very seldom used, and was in fact little more than a smuggler's track, scarcely deserving even to be called a path.

The track had been improved to a certain extent, and had been made practicable for animals for the greater part of its length. For the first five miles out of Gantok, it had been widened to a minimum of 10 feet and was well graded, but unfinished and unmetalled. From the fifth mile onwards it was a mere mule track, about 5 feet wide and on no particular grade, roughly paved with undressed stones as far as the Changu Lake (12,800 feet), twenty miles from Gantok (5,500 feet). This lake is an example of a very distinctive feature of the country; it is about a mile long by half as much broad, and very deep. There

* *Ekkas* are light two-wheeled native carts.

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are three or four others near the road above Changu, the last being close up under the Nathu La; and there are many other similar lakes among the hills in the neighbourhood.

At Changu the path ceased altogether, and there was nothing but an ill-defined cooly track till the pass was left behind and the path met again some two miles down on the other side. The distance from Changu to the top of the pass was about seven miles, two lower passes having to be crossed before the final ascent to the Nathu La was commenced. These minor passes, the Tunni La (13,200 feet) and the Sibbu La (13,750 feet), were across spurs which projected from the main feature, up the side of which ran the general line of the route. The Sibbu La was very steep and difficult, the Tunni comparatively easy.

The whole of the country on the Sikkim side of the pass is exceptionally difficult, the difficulties being exaggerated by the excessive rainfall, which, over a large part of the line, amounts to about 300 inches per annum. (At the time the work was started, the rainfall was at its worst). The portion above Changu was about as rough as can possibly be imagined, and it is a standing wonder how the animals were got over it in the early part of the year.

After crossing the Nathu La the country becomes much easier, and the track descended fairly easily for a couple of miles till a made path was again met about two miles from the Transport post of Champitong (13,200 feet). From Champitong the old path descended for some seven miles to strike the road at the bottom of the Chumbi Valley, about five miles from Chumbi and at an elevation of about 9,800 feet.

The first problem that presented itself was the lack of labour, almost the whole of the local labour having been taken up for Transport work in connection with the Mission. It was estimated that about 3,000 coolies would be required to get the road through by the end of October, which was the date fixed by the General Officer Commanding for completion. But only about 500 coolies could be obtained on the spot, and it appeared improbable that more than another 500 at most would ultimately be obtainable.

Proposals were made, and accepted by the Government of India, for the formation of two Cooly Corps of 1,000 men each, commanded by R.E. Officers. The original proposal was that a Corps of 2,000 Hazaras—the navvies of India, as they are called—should be raised; but it was not found possible to get enough of these. Finally two separate Corps were raised. One, under Lieut. L. N. Malan, R.E., was made up of 600 Pathans, recruited at Quetta, and 400 Garwhalis from round Mussoorie; this was known as the Mussoorie Cooly Corps. The other Corps was raised at Peshawar by Lieut. A. F. S. Hill, R.E., and mostly consisted of Pathans from near Peshawar.

These Corps arrived at the base at the beginning of August, and were despatched to Gantok in batches of 200 or so at a time. This

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arrangement did not work well, as officers were not available to accompany each batch, and a good deal of trouble ensued. The Peshawar coolies found the weight of their tents beyond their strength, and left them all behind, half way between Siliguri and Gantok. The Quetta Pathans brought up most of their tents, but varied the monotony of their march by getting up a free fight with some Sonthali coolies that they met on the way, in the course of which a village was burnt and several men injured.

The Field Engineer was now confronted with the depressing spectacle of some 1,000 odd men, who had no protection from the heavy and incessant rain beyond the clothes on their backs and their waterproof sheets. Fortunately there were a certain number of huts ready up the line, and others under construction, and into these the Peshawar coolies had to be crammed to wait for their tents. They were set to work on that part of the new line which happened to be near their huts. This proved in the end to be sheer waste of time, as, owing to the stoppage of the work, this part of the road was never finished.

The Mussoorie Corps was pushed up as it arrived, and was concentrated at a delectable spot called Yokontang, where the Transport coolies changed, just below the Nathu La and at a height of 13,200 feet. As the majority of the men came from a country where rain is almost unknown, they found some difficulty in appreciating the beauties of life in tents at this altitude and in continuous heavy rain; and they required a certain amount of forcible encouragement to bring them into a proper frame of mind. At the time they were enlisted they had a very hazy idea of where they were going and what they were going to do; one man fell out at Gantok, and explained that he had enlisted under the impression that he was joining a cavalry regiment!

While the Cooly Corps were being raised, the route had been thoroughly explored and the alignment of the road determined. Capt. P. E. Hodgson, R.E., had joined as Assistant Field Engineer, and had taken over the troublesome and unpleasant job of tracing the new road through the thick jungles on the Sikkim side of the pass. Between Changu and the Nathu La the country had been explored and a line marked out by Capt. Gillespie. On the Tibet side of the pass the line had been settled and a trace cut by half a company of the 1st (Bengal) Sappers and Miners under Lieut. E. F. J. Hill.

A very satisfactory line had been obtained right through, considering the nature of the country. The only real engineering difficulties occurred between the 7th and 12th miles; but even here, although the ground was very difficult, Capt. Hodgson had, after much trouble, found a practicable route. It was found possible to avoid almost entirely the difficult ground between Changu and the Nathu La, the new line being taken round the spurs which the old track had crossed at the Tunni La and Sibbu La; by this means the irritating ascents

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and descents of these passes were escaped, and an almost level road over quite easy ground was carried up to within a short distance of the Nathu La.

The tents of the Peshawar Corps gradually filtered up to Gantok, and by the end of the first week of September this Corps was under canvas and hard at work between Changu and Yokontang. The Mussoorie Corps were put on the length between Yokontang and the Nathu La, with the object of getting the highest part of the work done before the cold weather set in. The local coolies were at this time employed mostly on maintenance work and on carrying up rations and tools; as their numbers increased they were put on to Capt. Hodgson's piece of the road, where the foreign coolies would have been of little use owing to the nature of the jungle.

Towards the end of September rumours began to arrive that the work might possibly be stopped altogether, and it became practically certain that the road would not be completed as originally intended. Consequently all plans had to be changed, as it was obviously useless going on with any portion of the work that was likely to be left unfinished.

The part of the line on which Capt. Hodgson was engaged was abandoned, and the coolies were turned on to widening and improving the existing track between Gantok and Changu, metalling it throughout; some of them were sent over the pass to help on the further side. The Mussoorie Corps crossed the pass and started on the fifteen miles between the top of the pass and the village of Phema, where the route was to strike the road along the Chumbi Valley. The Peshawar Corps were left to finish the piece between Changu and the Nathu La. By these arrangements it was hoped that it would be possible to have a practicable road right through from Chumbi to Gantok by the end of the month, and to make a great portion of it passable for the Lhasa Column on their return journey to India.

The definite orders for stopping work on the original scale arrived on the 7th of October, giving the 31st of that month as the final day. By the time they arrived work was already in full swing on the new lines. The alignment had been changed wherever economy made it desirable; the width was reduced to 6 feet; and the maximum gradient fixed at 1 in 10 on such lengths as it was possible to re-align.

It was now a case of racing against time, and the road won by a narrow margin. The first party of the Lhasa Column crossed the pass in a heavy blizzard, and had an exceedingly hard time of it. The snow, which was quite unexpected, lay about three feet deep on the top of the pass, and stopped all work for several days. The unfortunate men of the Peshawar Cooly Corps, most of whom had never previously seen snow at close quarters, suffered severely; many of their tents came down under the weight of snow in the night, and their camp presented a dismal spectacle next morning. Fortunately

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for the troops, the road was finished sufficiently to enable them to avoid the Sibbu and Tunni La.

The road was open right through from Phema to Gantok on the 23rd of October, and General Macdonald left Chumbi on the 24th. After the General had gone through only a few days remained for work; these were spent in finishing up as far as possible and in repairing the damage caused by the storm. The effect of a heavy fall of snow and a hot sun on the surface of a newly-made unmetalled road was of course appalling; but considering the severity of the storm, it is satisfactory to record that no serious damage was done.

The Cooly Corps were started off on their homeward journeys at the end of the month; and all work was stopped, except as regards clearing up and collecting tools and surplus stores, which were taken down to Gantok and sold.

The total results of our labour were some 25 miles of road newly made and 20 miles of old track metalled, widened, and generally improved. In addition a good deal of work was done on the new line between Gantok and Changu, which was left in an unfinished state.

The most serious question that arose in connection with the work was that of the food supply of the 3,000 odd coolies employed. The country was uninhabited and everything had to be carried up from below. The original arrangement was that the Supply and Transport Corps should deliver all the required rations at Gantok and that the Field Engineer should arrange for its further carriage and distribution. Unfortunately, owing to the pressure on the Transport, the S. & T. Corps were unable to carry out their part of the arrangement, and the officer in charge of the road work was suddenly called upon to make all the arrangements for the supply of food. Without any staff of storekeepers this was a serious undertaking. However, contracts were made for supplies, godowns built, storekeepers improvised, and a regular supply and transport service instituted; the work required of this service was carried out with considerable success, no deaths from starvation being reported.

The quantities of stores dealt with were considerable. The food consumed by 1,000 coolies in one day was about 30 *maunds*,* and about 3,400 was the greatest number of men employed at any one time. This meant that over 90 *maunds* of rations alone had to be carried daily out of Gantok, and on an average as much again of tools and other stores.

The carrying was done partly by contract and partly by coolies working on a system similar to that employed by the S. & T. Corps, but somewhat simplified as regards office work. Each cooly carried one *maund* a day over a five-mile stage, each animal taking two *maunds* the same distance.

* A *maund* = 80 lbs.

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The furthest point at which stores were delivered was Champitong, 30 miles from Gantok. This distance required about 500 coolies and about 100 pack animals.

The greatest difficulty in connection with the stores was the absence of trained storekeepers. None were allowed in the original establishment, and they had to be extemporised out of any one that could be induced to take the job. They had to be taught their duties and to carry them out at the same time, which was not a convenient arrangement.

The supply of tools was a serious difficulty. When the work was ordered a large quantity of tools were ordered from Calcutta, and were sent off with commendable promptitude by the supplying firm. Unfortunately their arrival at the Base coincided with a period of great pressure on the S. & T. Corps and with bad blocks on the road up to Gantok, due to slips and breaks in the Testa Valley. The result was that many urgently wanted tools did not arrive till the work was over, and some never arrived at all. The worst trouble was due to the lack of blacksmiths' tools; this meant that for a long time there were no means of sharpening the hundreds of jumpers in daily use, and much delay and loss ensued.

The question of supervision of labour was also a difficult one. Practically there was one officer available for each thousand men. A thousand men at work on a narrow road inevitably get spread out over a considerable distance, amounting at times to as much as ten miles; when these ten miles are composed of ground over which a goat would have to be careful, it becomes a hard job for the officer. Three more officers were under orders to join on this account, but owing to the work being abandoned their orders were countermanded. In such a country as this road runs through, three officers per thousand coolies would be a fair allowance. For such work, where time is of the first importance, subordinates, whether European or Native, are of little use unless they happen to be picked men.

The British sergeants proved of great value on the supply and transport work, as they formed a check on the eccentricities of the Bengali *babus*.

An interesting feature of the work was the high altitude at which it was carried on. The greater part of the new road was at a height of over 13,000 feet, and many of the men were camped for a long time above this level. On the whole the altitude caused little trouble. At first the foreign coolies suffered to a small extent, but they soon got accustomed to the height; at the same time the amount of work of which they were capable must certainly have been less than at lower elevations. There was a slight difficulty in cooking some portions of the rations, notably *dhall* or lentils, which required extra boiling on account of the decreased pressure; but fortunately there was no difficulty in getting firewood.

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The principal lesson we learnt appears to be that, in an undertaking of this nature, it is a great advantage if all services in connection with the work can be carried out by those most nearly interested in it, and no dependence be placed on other departments.

If the food supply had been entrusted to the Field Engineer from the commencement, the enormous amount of trouble involved in having to make arrangements at a moment's notice would have been avoided. In the case of the tools it would have been quite easy to get them up from Siliguri by private arrangements, though of course the cost would have been considerable. Even with the best-managed Transport, hitches must occur in difficult country where the roads are bad; and when they do happen it must be a case of the most urgent things taking precedence. Of course it is not always possible or desirable to employ private agency; but when it is practicable there are many and great advantages to be gained in return for a certain amount of additional responsibility and a little extra work.

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THE TELEGRAPH SECTION, 1st SAPPERS AND MINERS, AT THE MEERUT DIVISIONAL MANŒUVRES, FEBRUARY, 1905.

By CAPT. B. W. MAINPRISE, R.E.

SINCE the Afghan War all Field Telegraph work required for Indian Frontier Expeditions has been carried out by the Government Telegraph Department, which occasionally employed such officers and men of the Sappers and Miners as were under instruction at the time in that department. The Director General of Telegraphs has had full control of such work, and the sending of Sappers on any expedition rested entirely with him. Under this system the Military Telegraph Sections, which form part of the organization of the three Corps of Sappers and Miners in India, had but little inducement to keep themselves efficient; their equipment was never used in the field, and the *personnel* only went on service as adjuncts to and under the orders of the civil staff of the Telegraph Department.

Considering that during peace time neither the necessary war *personnel* nor stores are a direct charge on the Military budget, this Civil Department has provided efficiently, and probably economically, what has until recently been considered a sufficiently good Telegraph service for a force acting on the frontier. This service has consisted of lines throughout the Lines of Communication and possibly to certain more or less permanent advance posts. There have been practically no mobile Telegraphs of any sort, not that they could not have been undertaken, but because their utility had not been understood.

In past years the advance of Telegraphy and, more especially, the growing use of Telephones have not been appreciated in India from a military standpoint, although the greatest attention has been paid to all forms of visual signalling. During the last five years, however, various attempts have been made to increase the utility of the Sapper Telegraph Sections. That these Sections could perform the required work when called upon was proved in the late China Expedition, where a fair mileage of semi-permanent line was erected and the existing lines repaired and maintained without assistance from the Civil Department. The Telephone equipment was found to be out of date and faulty; but when suitable instruments had been obtained, Telephones became very popular, and the maintenance of these is now

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the chief work of the Telegraph Section which is still maintained in North China.

The equipment of the Sapper Sections has lately been overhauled and increased, although it is still officially known as "instructional and for use at camps of exercise"; and some account of its employment last spring may be of interest.

For the Meerut Manœuvres (February, 1905) the Telegraph Section of the 1st S. & M. (under Lieut. D. A. Thomson, R.E.) was divided into two squads, each of 4 N.C.O.s and 12 Sappers with 5 military signallers (specially trained British privates). Each squad had 10 miles of air line and 5 miles of cable, with 2 officers, the whole being carried on 5 carts and 6 mules. An experimental Telephone unit, consisting of 4½ miles of cable and 3 Ericsson's portable telephones, carried on 4 mules, was attached to No. 2 Squad. Owing to the smallness of the manœuvre grant the Telegraph Section was only allowed to proceed to the manœuvres on condition that no extra expense was incurred; accordingly all its transport had to be found regimentally by attaching company mules.

On arrival it was found that there were three main camps, viz., (A) Headquarter Staff and No. 1 Brigade, (B) No. 2 Brigade, (C) Divisional Troops and Supply Depôt. A Central Telegraph Office was at once opened in camp (A) and connected to a spare wire running into the Delhi Government office, 12 miles distant, which wire the civil authorities had been good enough to place at our disposal. The site for a Central Telephone Exchange was also selected. Next day Field Telegraph Offices were opened in camps (B) and (C), distant about one and one and a-half miles respectively from the Central Office. Four Telephone Offices were also opened and connected through the Exchange.

These arrangements stood for nine days, during which the troops were exercised in field firing and brigade field days. On two of the latter occasions the Telephone unit was employed, and it was soon noticed how useful these units would be if there were at least two to each brigade.

On the tenth day the main body moved out to attack Delhi, leaving two detached parties to discover and retard a body of the enemy marching from Meerut to the relief of the former city. These two detached parties were placed in communication with each other by Telephone, and were connected by an air line with the main body moving on Delhi. The country was easy, so that the two air-line squads had no difficulty in keeping up with the main column. After advancing 9 miles the force fell back two miles and bivouacked at Shahdara for the night. Supplies were called up by Telegraph and were distributed before the troops marched out next morning, when the attack on Delhi was continued. On reaching the bridge over the Jumna outside Delhi, the "cease fire" was sounded, the troops

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marched back to their main camp at Ghaziabad, some 12 miles distant, and the air line was dismantled.

On the following day the attacking force concentrated at Loni, 10 miles from Ghaziabad. A Telegraph Office was opened here by noon, and the next day, when the force fought its way back to Ghaziabad, this line was dismantled again. On this day the Telephone unit was fully employed in keeping the Commander of the force in communication with his left flank, where most of the fighting took place.

On arrival in camp that evening, the Telephone unit was at once despatched by train to the Barkacha Artillery camp at the request of the Camp Commandant who wished to experiment in the use of telephones for control of battery fire.

The instruction and experience gained on these manœuvres was of the best possible kind; and the value of well-organized and properly-handled Telephone units, when employed well up with the firing line, cannot be overestimated. It must be the Telephone which has enabled the Japanese to fight so successfully over such extended fronts.

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THE RUSSO-TURKISH FRONTIER COMMISSION IN ASIA MINOR IN 1857–58.

By MAJOR-GENERAL E. RENOUARD JAMES, LATE R.E.

THE appointment of an International Commission for the delimitation and demarcation of the Russo-Turkish frontier in Asia Minor was a consequence of the war of 1854–6. The British Section was composed as follows :—

Lieut.-Colonel J. L. A. Simmons, R.E. (the late Field Marshal), Commissioner.
Lieut. E. R. James, R.E.,
Lieut. C. G. Gordon, R.E., } Attached.
Lieut. H. Helsham-Jones, R.E.,
A party of Sappers and Miners.
Assist.-Surgeon S. Woodfull, R.A.
Captain De Normann, for the Foreign Office.
Mr. Stabb,
Mr. Hidayet, } Interpreters.

The party reached Trebizond in May, 1857, and marched from there, by way of Erzeroom and Kars, to Alexandrapol, a point on the frontier where the several Commissioners had agreed to meet. From Alexandrapol, the joint body followed the line of frontier southwards to Mount Ararat; and then, after returning to the starting point, northwards to Fort St. Nikolas on the coast of the Black Sea, where the work of 1857 was finished and the Commission broke up. In 1858, Lieuts. James and Gordon returned to the country to act as arbiters in the demarcation of the frontier by Russian and Turkish topographical officers.

On the completion of the labours of the Commission, a mass of barometrical and other observations for determining the altitudes in the country traversed by the English Section remained in my hands, as no one seemed to want them. I always intended to work out results from them, but in the pressure of my official life, I was unable to devote enough time to the study of the subject to do so thoroughly. In 1859, I joined the Ordnance Survey, and made an effort to do something with the assistance of the late Sergt.-Major J. Steel, R.E., one of the ablest calculators ever attached to the Southampton staff, who sent me a very learned memorandum on the calculation of

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altitudes from barometrical observations and supplied me with some valuable formulæ. I found, however, that much labour was still necessary before satisfactory results could be worked out and tabulated; and the difficulties involved in the minute corrections enjoined in the text-books were so great that I was compelled, again and again, to defer the matter to "a more convenient season." It thus happens that I offer the following notes rather late in the day. My original purpose in commencing this paper was simply the determination of the altitudes; but the stirring up of my memory in regard to events which occurred nearly half a century ago leads me to think that a short account of the share of the Royal Engineer officers in the work of the Commission of 1857–8, which has not been previously given in the Corps publications, may not be entirely without interest to my brother officers.

The accompanying skeleton map of the country traversed shows that the English Section passed through three main geographical basins, those of the Black Sea, the Persian Gulf, and the Caspian Sea; and visited a district of great historical and geographical interest.

Between Trebizond and Erzeroom three principal watershed lines were crossed at altitudes varying from 6,300 to 8,336 feet above sea level, the plain of Erzeroom, in the basin of the Persian Gulf, being over 6,000. In the march to Kars, the pass of Soghanli Dagh is at an elevation of nearly 8,300 feet. Along the course of the Araxes, in the Caspian Sea basin, the height fell below 3,000 feet; but the mountains on either side, Mount Ararat and Mount Alagos, reached altitudes of 16,950 and 12,820 respectively. On the northern portion of the frontier, the Commission remained encamped for a considerable period at altitudes varying from 7,000 to 8,000 feet. In the course of the marches, many places of high interest were visited.

Starting from Trebizond, a place rich in Greek, Genoese, and Byzantine remains, and once the capital of the mysterious Empire under the rule of the Comneni, where a pack caravan was organized, the Section on the third day crossed the Zigana Dagh pass at a height of 6,611 feet. This mountain is noted as the point at which the army of Xenophon came suddenly, after tedious months of marching, within sight of the Black Sea. On its slopes grow the splendid rhododendrons and azaleas, from which the intoxicating honey that maddened the Greek soldiers was made.

Near Gumüsch Tchaneh, with its orchards and silver mines, Xenophon had a fight with the local tribes.

Before reaching Baibürt, the pass of Tchadrak was crossed by us. Although the lowest in altitude of the three between Trebizond and Erzeroom, it is the chief in strategic importance, as an army approaching by the valley of the Tchoruk Sou (which would be a probable route under present conditions) could, by seizing this pass, turn both Trebizond and Erzeroom, and gain a point within easy reach of

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Erzingan. From the last-named place, a spring forward down the Euphrates Valley would enable it to occupy the line between Erzingan and the Mediterranean, and, by dividing the Turkish dominions in Asia Minor in half, isolate Constantinople.

Descending the valley of the Tchoruk Sou a few miles, the Section passed Baïburt, which is noted as the most advanced point reached by the army of Paskiewitch in 1828; and crossed the dangerous pass of Khoshabounar Dagh, at an elevation of 8,522 feet, to the plain of Erzeroom, on which the Euphrates takes its rise. The altitude of this plain exceeds 6,000 feet. Local traditions say it is the site of the Garden of Eden, but no argument can be adduced in favour of such an idea except that at Bac Dagh, a neighbouring mountain, which I assume to be approximately 9,000 feet above sea level, the watershed lines separating three seas converge, while a very short distance westward another—that of the Mediterranean Sea—is to be found. The country round Erzeroom is a sterile, treeless waste now, producing at the best some miserable crops of grain on the plain. The city, the modern capital of Armenia, possesses some fine examples of ancient buildings—so-called Genoese, Saracenic, and Armenian—which frequent earthquakes have left in a semi-ruinous condition.

Soon after leaving Erzeroom, the Section passed the position of Devèh Bouinoŭ, on the watershed line between the Persian Gulf and the Caspian Sea, at a comparatively low altitude, estimated at 6,500 feet; but over a pass which for ages has been of strategical importance. Having made a careful study of the events of Xenophon's march, from a translation of the Anabasis by A. J. Valpy, published in 1830, I find every reason to consider that it was at this very pass that the disciplined Greek Army made a successful assault against the tribes assembled to oppose its advance; and the tactics used in turning the position defended seem to have been precisely similar to those employed by the Russians at the same place. In the war of 1854–6, the Turks fortified the pass, and as the Section of the Commission crossed it the remains of the redoubts which were erected were still visible. When this pass is taken Erzeroom is at the mercy of an invading army. Mention has been made by me of the importance of the Tchadrak pass also, and, with the advantageous situation of her frontier at present, Russia, in a future war, would probably be in possession of both positions before Turkey had awakened from her customary lethargy. Russia appears to wage war in Asia Minor every twenty-five years or so (*e.g.*, 1828; 1854; 1877); possibly she will find a pretext some day for getting on to Erzingan; and after that, with a like interval, she may endeavour to acquire the Mediterranean port she has been so long dreaming of, which would probably be at Iskanderoom opposite Cyprus.

Descending the head waters of the Araxes, in the Caspian Sea basin, the main river was reached near the point at which Xenophon's

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army, coming the reverse way from a pass leading from the valley of the Upper Tigris, arrived on its bank. Not far from the same place there is a ruin known as "The Tower of the Son of Cyrus," the name of which seemed to indicate the former existence of a tradition in connection with the retreat of the 10,000; but we were unable to ascertain if this were still extant. At the same point we diverged from the great pack-road, by which long trains of heavily laden animals carried carpets, spices, and Oriental goods from Persia to the Black Sea along the exact route we had followed from Trebizond. The dangerous passes of Zigana and Khoshabounar are not free of snow until late in spring, and many pack-horses are sacrificed in crossing them. We had, with the Section, a train of about a hundred pack and saddle horses; for there was no wheeled transport to be had in the country, and, in fact, no vehicles of any sort except some very primitive carts with solid wheels, which we saw in use by the peasants on the high plains. The pack-horse traffic of this part of Asiatic Turkey is in a declining condition; for, since Russia has gained possession of Batoum, she has constructed railways connecting Persia with the Black Sea, and the flow of commerce is rapidly changing its direction. The Turkish Government has displayed its customary apathy in failing to do anything to maintain so important a line of commerce, and nothing could now be done which would restore it to its former prosperity.

Leaving the Araxes, the Section entered a mountain district, through which the track was even rougher than those we had already traversed. There were no formed roads at all, unless a single mile of old *chaussèe*, leading out of Trebizond, could be called such. The story about this is that a certain Pacha, having been ordered to make a good road to Erzeroom, had, after much enforced labour and many exactions, ended his efforts with the very small result apparent. His first duty, he considered, was to make his own fortune before he was removed from his post through the intrigues of some other pacha hoping to succeed him, this being the customary rule of every government official in Turkey. The *chaussèe* had become impassable, and the pack animals picked their way outside its rough stones.

The direction of tracks in Turkey is often peculiar, and the road the Section ascended to the pass of Soghanli Dagh seemed a very strange one to reach Kars by, when by following the course of the Araxes we might have got there on comparatively level ground. For this reason the pass named, as long as it was in Turkish hands, could be readily turned by a Russian column and offered a very slight obstacle to invasion. On reaching its summits, for there are two at an altitude of 8,261 feet, the track passes for a short way along the *versant* of the Black Sea. There is no vegetation, and the ground is covered with lava, pumice stone, and scoriæ, and especially with obsidian, the sharp-edged chips of which resemble black bottle-glass. The horses' feet

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sunk in the loose volcanic refuse, and the animals, who slipped and stumbled at every step, would have been wounded if they had not been shod with flat plates of iron in the Turkish method. The plain of Kars, 2,000 feet down, was reached at break-neck speed.

Lieuts. James and Gordon were left at Kars with instructions to make a survey of the place, but were called on to Alexandrapol before they had time to do more than make a commencement of the task. The few days' delay gave them an opportunity for studying the positions held by the Turkish Army during the ever-memorable defence of the place, under the advice of Sir William Fenwick Williams, in 1855. The "Narrative of the Siege" was told by Sandwith in a book with that title, published in 1856, an abstract of which with a plan was printed in the *Royal Engineers Journal*. I need not, therefore, do more than offer some general remarks on the famous incident. The ancient Genoese citadel, on a height surrounded by a bend of the Kars Tchai, commands the town; but is itself commanded in every direction by the neighbouring hills at distances of from 2,000 to 3,000 yards. Although smooth-bore ordnance was in use in 1855, the power of artillery had already commenced to advance, and it was essential to occupy the commanding points in order to make a proper defence. The entire fortified position covered a circular space round the citadel of an area of seven square miles, the longest diagonal of which was roughly 6,000 yards. There were nine redoubts on an outer line, and four on an inner line, in advance of the citadel and town. The establishment of such a circuit of detached works, mutually supporting each other, was an early—if not the earliest—example of a modern fortress of the kind. The Turkish army was 15,000 strong, insufficiently supplied both with ammunition and food, and the soldiers were in rags and in an enfeebled condition of health. The proper defence of the too-extended line with so small a force was impossible, yet the features of the ground were such that the effective occupation of any shorter line would have been a most difficult problem; and it seems questionable whether it was not a mistake to attempt to hold Kars at all, locking up a force there which might have been profitably employed in field operations. The gallant defenders held the place, however, from June to November, and were only constrained to surrender by disease and starvation. The Russians besieging the fortress were greatly in excess of the garrison in numbers; and the failure of Mouravieff, their commander, to take it sooner can only be accounted for by his absolute incapacity.

In studying the problems of Kars, the officers of the English Section of the Commission could not fail to observe that the successful campaign in Mingrelia, and victory on the Ingour in 1855, in which our chief, Colonel Simmons, had been the moving spirit in the army of Omar Pacha, must have been an important factor in causing Mouravieff to fail. With Omar Pacha on his flank and rear, the

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Russian force was necessarily in danger of being isolated. Many critics of the conduct of the war of 1854–6 were of opinion that the main theatre of operations against Russia should have been in the Trans-Caucasian province, which she held at the end of a slender thread of communications through mountains occupied for the greater part by the hardy Circassian, Lesghian, Tchechnian and Daghistan tribes, under the famous chief Schamyl. It was believed by some, and on very good grounds, that the mountaineers were anxious to declare themselves for Turkey, and would have done so if they had been supported in force by the Western armies. It was argued by the advocates of an invasion of Georgia that it would have resulted in Russia losing her entire territory south of the Caucasus mountains; and, from my conversations with Simmons, I was always under the impression that he would have favoured such a strategical operation very warmly. We know, with certainty, how he urged in vain that the army of Omar Pacha should be strongly supported by the Allies, for he knew the small force in Mingrelia could do but little by itself. This little, however, it performed to the fullest extent possible under his own splendid guidance.

The entire Commission assembled at Alexandrapol on the frontier, the British Section having marched about 350 miles. The representatives of the Powers concerned in the delimitation were Simmons for England, M. Pelissier for France, Hussein Pacha for Turkey, and General Tchirikoff for Russia; and attached to each was a staff of topographical officers. On the Russian side a squadron of Cossacks of the Black Sea acted as escort, and on the Turkish side one of cavalry. The Commission remained a few days at Alexandrapol to exchange powers, and constitute the order of proceedings; and during this period visits of ceremony were paid and received.

A small fortress with Vauban fronts commanded the valley of the Arpa Tchai and the approach from the direction of Kars. It was agreed that the thalweg of the river named should form the frontier from Alexandrapol for 45 miles southwards to the confluence of the stream with the Araxes; and along this part of the line the topographical officers had merely to verify the map supplied by the Russian Commissioner. The whole body made a leisurely march of four days to Hadji Bairam, resting the whole of one at Kizil Kilissa on the left bank to afford us an opportunity of visiting the ruined city of Ani on the Turkish side of the frontier. A sight of this place, which occupies a defensive situation on a triangular space enclosed by cliffs and encircled by a bend of the Arpa Tchai, was, to myself at least, worth all the fatigues of our long journey on horseback. Absolutely deserted when we saw it, except by a few nomadic shepherds, it was said to have once had a population of 100,000; and the magnificence of its remains attest that this might have been the case. A line of solid walls still stands across the base of the triangle, and

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some twenty large buildings, described to us as—"The Cathedral of the Patriarchs," "The King's Palace," "The King's Chapel," "The Chief Mosque," "The Armenian Church," etc.,—are still in good condition. They are built in variously coloured lavas, in chequered courses, carved in geometrical designs or with inscriptions in Armenian and Arabic. In the case of the Chief Mosque, an inscription copied and translated for me afforded proof of an antiquity of nearly one thousand years. Ani, the seat of the monarchs of ancient Armenia, was founded at the period of the introduction of Christianity by St. Gregory. It fell, in turn, under the power of Saracens, Osmanli, Armenians, Georgians, and Persians, until a disastrous earthquake caused its abandonment in the 15th century. It must rank in antiquarian interest with such places as Pompeii, Herculeaneum, and our own Silchester. The Turks did nothing to preserve the ruins; but since 1878 Ani has become Russian property, and it is to be hoped is now well cared for. I visited the place a second time in 1858, and had leisure to take some sketches and photographs.

The Commission halted at Hadji Bairam on the Araxes, and from that place ascended the river for a few miles westward to Parnaout, from near which place one of the rivulets flowing from the crest of the Ararat range was decided on as the frontier. It ran through a district of wild mountain scenery, inhabited in summer by pastoral Kurds, and there was some delay while negotiations were conducted with the chiefs in regard to the ownership of the pasturage in the upland valleys. It had been decided to give the tribes the option of choosing their future nationality after the delimitation had been made, and proof of ownership became a valid qualification for applications to become subjects of either Russia or Turkey. Evidence, which was frequently false on both sides, was given by the representatives of the tribes affected, and a kind of "give-and-take" line was ultimately decided on for the frontier. Whether the line was a watershed division or a thalweg, the claim of a pastoral tribe to the ownership of a prairie on one side, while they remained subjects of the other, could not be logically upheld. The evidence before the Commission proved that the Kurds preferred to become nominal subjects of Turkey, as they would then be "a law unto themselves." The Bashi Bazouks, or irregular cavalry of Turkey, were largely recruited from the Turkish Kurds; while on the Russian side, though excused from obligatory service, the mountain tribes were encouraged by heavy bribes to join the army. We saw much of the Kurds, especially those of the tribe of Yezidis, or demon and sun worshippers, and frequently visited them in their black camels' hair tents, which were primitive enough to be such as were dwelt in by Father Abraham. With our escort, we could go into their encampments without fear, but we knew them to be brigands of the most dangerous sort.

The Commission reached the watershed line of the Ararat range, at

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a point nearly fifty miles westward of the chief mountain, Great Ararat, which had been visible to us for some time, and for several weeks after this we did not lose sight of its conical snow-clad summit. Perli Dagh, near which we first arrived on the range, is a mountain about 10,500 feet in altitude, easy of ascent on horseback; we were therefore able, without any difficulty, to take an observation of the temperature of boiling water at its apex. We marched on Turkish ground a little to the south of the ridge, halting at Balÿk Gol, a large lake, and other places. We made an excursion to Bayazid, a town of importance, which has played an ignoble part in the wars between Turkey and Russia, and saw there the remains of two fine palaces. Keeping round the base of Great Ararat, we encamped on the pass of Sardar Boulak, directly between the greater and lesser summits, at an altitude of 8,000 feet. The first mountain, 16,950 feet above the sea according to Russian measurement, rose to our west in a magnificent cone everlastingly capped with snow; while the second, 12,865 feet high but easy of ascent, the point of junction of the three frontiers of Turkey, Russia, and Persia, was on our east side. Our tents were pitched in a deep depression between the two peaks, which, in eagle-flight, are not nine miles apart. Early every afternoon, as we fell into the shadow of the great mountain, the temperature of the air dropped rapidly from July heat, and continued to do so until it was almost at freezing point. After this change had commenced, a curious and anomalous phenomenon was observed in the commencement of a flow of water in channels near the camp which had remained dry until about 3.0 p.m. The rays of the morning sun had melted some of the snow at the high levels, but the running water had not had time to reach so far until this late hour. It would continue to flow past us for two or three hours, after which the watercourses would again dry up. The treeless scenery round Ararat has an awe-like solemnity; the distant prospect of the Araxes Valley, with the river stretching far away, and Mount Alagos on the north, 57 miles distant, standing out sharply in the clear atmosphere. The local traditions in connection with the Biblical Story of the Flood are said to date from the foundation of Armenian Christianity in the 4th century only, but are very firmly established in the minds of the dwellers in the district—Armenians, Persians, and Kürds alike—who point to the names of villages round the mountain as affording incontestable proof of their truth. The names are, among others, as follows:—"The place where Noah built an Altar"; "Noah planted the Vine at this place"; "The Burial Place of Sarai."

Leaving Sardar Boulak the Commission returned to Alexandrapol by a direct route. Crossing the plain of the Araxes at less than 3,000 feet above sea level, a halt was made at Etchmiadzin, the cradle of the Armenian faith, where, in the grand Cathedral of St. Gregory, the founder of the religion, many sacred relics are preserved. The most

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treasured of these is believed by good Armenians to be a fragment of the Ark, the legend concerning it being that St. Yakob, a monk contemporary with Gregory, received it from the actual hand of the angel Gabriel. Yakob, ascending Mount Ararat, was met by the angel at the snow level, and, after being admonished for his impious attempt to perform a feat forbidden to mortal man, was presented with the relic for the preservation of his faith. It was shewn to us by the Patriarch Nerses, who entertained us hospitably and displayed the riches of the monastery and the celebrated manuscripts there.

The impossibility of making the ascent of Ararat is held as a dogma by the poor Kurds and Armenians, who, although they acknowledge to have seen persons on the summit with their own eyes, persist that their appearance there was a deception, due to the evil spirits of the mountain, which they would imperil their immortal souls by believing to be true. Time has brought them to the belief that it was the Patriarch Jacob, and not the Armenian monk Yakob, who received the relic from Gabriel. The monks at Etchmiadzin do not share these beliefs, although they do not seem to discourage them. The ascent of Ararat was undoubtedly made by Dr. Parrott, a Russian savant, in 1828, whose success was attested by sworn evidence. None of our party reached the summit; Corporal Fisher, R.E., honestly imagined he had done so, but we did not quite accept the fact as proved; Gordon, in 1857, admitted having failed; and Dr. Woodfall and myself, in 1858, did so also, although we reached an altitude we estimated as about 16,000 feet above the sea. The superstitious fears of the Kurds prevent their going beyond the snow line; and they are therefore not of any service as guides. To skilful Swiss climbers, provided with the proper appliances, the ascent is not difficult, and it has been accomplished since I was in the country by members of the Alpine Club.

The notes I made at Etchmiadzin of the ancient history of the Armenian nation would require an article to themselves. From there we made an excursion to Erivan, the capital of the Persian province acquired for Russia by Paskiewitch in 1828, a most interesting place. We there saw remarkable types of Persian architecture in the ancient mosques and the Salamlik of the old Sirdars, in which coloured lavas and tiles were lavishly used; and we found a novelty in the Persian life in the bazaars, which greatly charmed us.

Returning to our road, we made a halt at Kazafar, under the shadow of Mount Alagos, a mountain approximately 13,450 feet in altitude. I was one of three English officers who made its ascent, with a Cossack who dared not disobey orders; but the Russian officers and our Hungarian interpreter, who commenced it with us, were soon tired of the exertion necessary to climb up a jagged ridge of rocks jutting out from the snow, so the four first spoken of reached the top alone. We fired off the Cossack's musket as a signal to the

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camp, and ascertained the temperature of boiling water. The view was splendid. The descent by the same rugged rocks was difficult, as we had to drop from ledge to ledge with care. Charles George Gordon, with his characteristic impatience at our slow progress, seated himself on a steep snow slope, and commenced sliding down before Dr. Woodfall and I could stop him. We held our breath in terror as he was carried down with great velocity and we lost sight of him as he shot over a ridge which concealed him from our view. We continued the slow descent, with much anxiety as to his fate, and I cannot express the relief it was to our overstrained nerves when he met us, smiling as if nothing unusual had happened. It appeared that, after sliding down for possibly a thousand feet, he had been carried on to a smooth rising slope where his descent had stopped. His life's history might have been a very different one if he had not escaped so providentially.

The Commission did not stay long at Alexandrapol on its second visit, but moved northwards along the frontier, which ascended the Arpa Tchai to near its source and afterwards followed the line of crests separating generally the basins of the Black and Caspian Seas; the highest point was Gumbet Tepi, about 9,800 above sea level. The district traversed, known by the name of Adjara, lies to the south of Georgia and contains the large towns of Akhaltzik and Akhalkhalaka. In natural beauty this country exceeded every part of Asia Minor we saw, for it had in succession the most picturesque hill and dale, river and lake, covered with forest in which the virgin trees were of indescribable grandeur. In many places the smooth hog-backed crests formed the only road; we constantly encamped on them at high altitudes, enjoying the loveliest views conceivable from our tent doors. In any western land such a district would have long ago become the resort of the tourist, but the absence of hotels and roads tended to enhance its charms to us. The frontier dropped at a few points, between height and height, and crossed the valleys of the tributaries of the Kur, which find a meeting near Akhaltzik, from whence the river, after passing Tiflis, about 160 miles on its course lower down, flows on towards the Caspian Sea.

A halt of some days was made at Akhaltzik, the chief town of a district of Georgia, where there is a garrison and civil administration. The place is remarkable for having been the scene of the heartless massacre of its inhabitants by the Russians in 1828. It is now the centre of the manufacture of the artistic silver work generally known as Caucasus Niello, which is much used in the ornamentation of sword hilts and arms. At Akhaltzik, I experienced the greatest grief in the death of my valuable servant, Sapper Crompton, who died in the Russian military hospital from the effects of a gun accident. He had followed my fortunes for two years, and I was much attached to him, for he was a splendid soldier and typically a "handy man."

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The Commission finished the clerical work of the delimitation at Osurgeth, capital of the province of Guriel, where we stayed ten days. While there the English Section gave a final entertainment to our colleagues and the local gentry; this was the greatest success, and afforded us a favourable opportunity for noting some curious customs of the Georgian people and seeing our guests in their gala costumes. The title "Knaz" is that which they use to designate a landowner of importance, but we translated this into "Prince"; and we had twenty "Princes" and a dozen "Princesses" at our gathering, the main feature of which was an excessive consumption of Kaheti wine by the men after the departure of the ladies, who first amused us by dancing *pas seuls* in their own peculiar fashion.

We marched along the coast to Batoum, where we embarked for Constantinople. In 1857, Batoum was in Turkish hands. It became Russian in 1878 and is now connected with Tiflis and the petroleum wells at Baku on the Caspian shore, as well as with Alexandrapol, Kars and Erivan, by lines of railway, which must greatly affect the prosperity of the Turkish pack-trade between Persia and Trebizond.

I have already mentioned that Gordon and I returned to Asia Minor in 1858 to act as arbiters in the demarcation of the frontier. We went over all the ground a second time, but did not take any more barometrical observations. The line of boundary was indicated by "Marques de Bornage," built where deemed necessary, and these were described in a "Cahier de Specification," the marks being fixed by the bearings of "Points de Repère." The plans and other documents were signed "en triple expedition" by "Messieurs les Commissaires Demarcateurs," and the English copy is no doubt in some pigeon-hole at the Foreign Office. But the frontier line, with which we took so much trouble in 1857–8, ceased to exist as such in 1878, when Russia acquired the additional territory shewn on the map I append.

After concluding our labours at Alexandrapol, Gordon and I marched through the provinces of Kars and Ardahan, which are now Russian, and reached the Black Sea at Batoum by way of the Tchorŭk Sou. As we approached the coast, the country was so densely wooded that we found it impossible to get further than Artwin with pack horses; and on reaching that place there was no alternative, except a very long circuit by way of Baibürt to Trebizond, to embarkation in the most primitive of canoes and a rather hazardous voyage down the Tchorŭk Sou to Batoum. As the season was getting late for crossing the mountain passes, we decided on the river; and after selling our horses and most of our stores at a great loss, we reached the sea in two days. We heard that this route had never been chosen by other western travellers before that date; and as, by this time, the Russians have doubtless made a road for wheel traffic between Batoum and Artwin, the chance of making such an exciting voyage is now past.

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Before we left the country, I accompanied Gordon in a trip with a hired carriage to Tiflis, the capital of the Trans-Caucasian Government, where we were hospitably received by our friend Baron Finôt, the French Consul, who had been our guest in camp the year before; under his guidance we enjoyed several days in the city very pleasantly.

The remainder of Major-General James' article consists of technical details regarding the determination of the altitudes from the various observations recorded by the British Section of the Boundary Commission. In the course of the summer barometrical readings were recorded three times daily, at altitudes varying from sea-level to almost 10,000 feet; and at a few of the higher points the temperature at which water boiled was observed. As the methods employed in calculation have been greatly simplified since 1855, it is unnecessary, now, to give the details *in extenso*.

As regards the formulæ used by Major-General James, an adaptation of his own from one deduced by Serjt.-Major J. Steel, R.E., from the theories of Laplace, Vince, Allinson, Dalton and others gave fairly good results; and the calculated heights obtained by this formula are compared with those by several other methods in a lengthy table for which there is not space. One of the other methods,—and, apparently, that which on the whole produced the most satisfactory results,—is the rule given in the *R.E. Aide Memoire* of 1876 (Part I., Article 95), and a selection of the heights obtained by this method has been made for the accompanying map. A few of the altitudes, however, have been taken from Russian sources or from calculations based on the Boiling Water temperatures.

From the circumstances under which the records were made, the impossibility of comparing those at the lower station (Trebizond) with the observed upper readings at once became evident; and the application of the usual corrections would have been futile. In fact, the altitudes obtained by applying a deduced table of multipliers (not printed) to the approximations found by the mere subtraction of the observed barometrical readings from 30,000 compare with surprising accuracy with the results by the best of the other methods. The heights obtained from the Boiling Water temperatures are less reliable, and have been rejected for the map when others were available.

Major-General James justly states "heights obtained by barometrical and thermometrical observations, although they afford an approximation to the truth, cannot be assumed accurate enough to bear comparison with those determined by spirit-levelling or vertical angles." Accepting this principle, most geographers are agreed that it is not material to elaborate a formula, it being recognized that the investigation, originally worked out by Laplace, is a simple problem in hydrostatics not capable of producing absolute accuracy. Simple tables have, therefore, been framed for travellers, those most in use by British surveyors being due to Baily. There are well-known tables, also, by Williamson, Guyot, and others. Mr. Gilbert, of the United States Geological Survey, has recently brought

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forward a new method, depending on the employment of two base barometer stations,* which is said to produce satisfactory results.

Details are also given in Major-General James' article of the instruments employed in 1855; and the difficulties experienced by the British Section will be understood when it is stated that the last of the seven mountain barometers which remained serviceable was broken a week before the return of the Commission to the sea level.

Edr., R.E.J.

* See *Topographic Surveying*, by H. M. Wilson (Wiley & Sons, New York).

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AN EARTHQUAKE THEORY.

By Capt. H. L. Crosthwait, R.E.

After an earthquake one is naturally impelled to ask the questions :— What is the cause of seismic disturbances ? What agency, or agencies, are at work to produce such far-reaching effects, sufficient to be felt, or at least instrumentally recorded, all over our planet ? A complete answer is, of course, not forthcoming. All it is proposed to do in this paper is to point out what appears to be the most probable direction in which to look for a solution of a problem that must always be most fascinating.

Direct observation has not contributed much. It has been truly said that, if we were to visit the scene of one of the most appalling disasters after a lapse of, say, two years or so, when houses had been rebuilt and artificial structures generally repaired, it would be almost impossible to tell that anything had taken place. It is the works of man that suffer most. The severest shock has so little apparent permanent effect on the crust of the earth that it requires a trained eye, and often delicate measurements, to detect it ; though there are indeed some notable exceptions, such as Allah Bund in the Sind desert, the result of an earthquake that occurred in the first half of the last century.

Although observations have not done much to unravel the cause, they have solved such questions as the depth of the disturbance below the surface and the rate of propagation of the seismic waves. But this subject is much obscured and complicated by the nature of the waves themselves and by the want of homogeneity of the medium through which they have to travel.

If we want an intelligible explanation we must look to theoretical considerations. There is a theory, dependent on a mathematical demonstration, which appears best to account for the phenomenon. It is this that it is proposed briefly to explain.

In a paper entitled "The Distribution of Strain in the Earth's Crust, resulting from Secular Cooling,"* based on the theoretical researches of Lord Kelvin and Professor G. H. Darwin, Mr. C. Davison has shown that the *rate* at which the earth loses heat increases with the depth below the surface up to a certain point, when it becomes a maximum, after which it decreases towards the

* *Philosophical Transactions*, Vol. 178.

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centre. The depth of the position of the greatest rate of cooling constantly increases, and "varies as the square root of the time which has elapsed since the consolidation of the globe." This seems a remarkable result. It has been arrived at by purely mathematical reasoning, and is vouched for by the highest authority. It will account not only for most of the seismic phenomena but also for features in the configuration of the earth's crust.

Suppose the crust of the earth to be divided into a series of thin concentric shells.* Consider two consecutive shells situated above the point of maximum rate of cooling. As they are losing heat at different rates, there must also be different rates of contraction. The inner surface of the outer shell (which loses heat at a slower rate) contracts less than the outer surface of the interior shell. The result is that the exterior shell is thrown into a state of compressive strain. Apply this reasoning to the crust of the earth as a whole, and we have an outer solid shell ever endeavouring to accommodate itself to a smaller interior. In other words, there is a constant tendency to disturb the existing state of equilibrium; but whenever such is the case there is also always a tendency towards its readjustment.

Here there are all the elements of an earthquake. When an attempt to restore equilibrium takes place the result is a seismic shock.

As the cooling continues the strain on the earth's crust becomes greater and greater; a time comes when resistance can no longer be maintained, and then rupture ensues along some line of weakness. A slip takes place, and the outer crust suddenly endeavours to accommodate itself to new conditions, which it has perhaps been striving after for a long series of ages. Equilibrium is probably never fully attained because the processes are never completed.

Observation seems to indicate that these lines of weakness are coincident with the great mountain ranges of the earth. In fact the forces that cause seismic disturbances may also produce the crumpling of the crust which we call mountains.

There would seem to be a further subsidiary cause at work, tending to make earthquakes more frequent in the neighbourhood of mountain ranges. In the process of denudation, which is always going on, enormous masses of alluvial matter are continually being transported from the hills and distributed over lower ground. This must, in the course of time, alter the relative distribution of weight on the portion of the earth's crust concerned. It is something like moving material from the crown of an arch and placing it on the haunches; when a certain amount has been removed a place of weakness is developed, and finally fracture occurs. So it is with the earth's crust. By the action of the process indicated, what were probably natural zones of

* Each shell is assumed to be so thin that its rate of cooling is uniform.

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weakness become intensified and less able to resist the strains they have to bear. In the case of the Himalayas the haunches of the arch may be represented by the great Bhábar* deposits, known to be thousands of feet thick, which lie at the foot of this range. Professor Milne† instances a case, in Japan, where frequent earthquakes have their origin near the mouth of a river. It is known that this river is constantly depositing immense masses of material at its mouth, thereby altering the relative distribution of weights.

With regard to the theory itself Professor Darwin remarks "the stretching and probable fracture of the strata at some miles below the surface will allow of the injection of lower rocks among the upper ones; and the phenomena which we should expect to find, according to the theory of Mr. Davison, are eminently in accordance with observation. It therefore appears to me that his view has a strong claim to acceptance."

To say that the theory of secular cooling as a cause of seismic disturbance has been accepted by geologists would be perhaps to overstate the case. They are naturally, and not without reason, very cautious. The list of accepted theories is small, and seldom suffers enlargement; but the theory in question may be said to occupy an honourable place in dynamical geology among the causes usually discussed.

* These deposits represent the results of continued denudation of the mountains.

† *Encyclopædia Britannica.*

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TRANSCRIPTS.

PRECAUTIONS AGAINST FEVERS.*

As mosquitoes and flies undoubtedly carry disease, such as Malarial, Enteric, and Yellow Fevers, etc., I would suggest that it is advisable to attack these pests as far as possible.

1. Mosquitoes breed only in water, usually in that standing in artificial places.

2. Mosquitoes occur in the vicinity in which they breed. Invasions from long distances are exceptional.

3. The young mosquito lives in water from seven to twelve days.

4. Destroy the breeding places, and you will destroy the mosquitoes.

5. Empty the water from all tubs, buckets, cans, flower vases, etc., once in every 48 hours.

6. Fill or drain all places where water stands.

7. Change regularly every day all water needed in hen coops, dog kennels, etc.

8. Clean away weeds, grass and undergrowth about ditches, ponds and other possible breeding places, since they afford a hiding place for the adult mosquitoes.

9. Keep the vicinity of your house clear of all cans, tins, bottles and rubbish.

10. Tubs used for catching water, and which are in daily use, should be covered with a fine wire netting. Water from such tubs should not be used for cooking or drinking purposes, and the water in the tub may be treated with paraffin oil.

11. Any pond in the grounds which cannot be drained or filled in should be treated with a little paraffin oil; an ounce of oil will spread over about 12 square feet of water.

Flies as well as mosquitoes carry disease into houses, and a common method of introducing it is by food contamination.

All meat and other eatables should be kept in a fly-proof safe, and even when on a sideboard they should be protected by wire gauze meat covers or pieces of muslin.

Great care should be exercised in keeping the kitchen premises very clean; any refuse left exposed outside will attract flies, and these will settle on food in the kitchen.

* We are indebted to Colonel E. Harrold Fenn, C.I.E., R.A.M.C., Administrative Medical Officer, Chatham, for permission to publish these notes, which he has issued officially to drafts proceeding abroad from Chatham.

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Milk should be carefully protected from flies.

Enormous numbers of flies can be destroyed daily by using fly papers or fly traps.

General Precautions.

Water.—Never drink doubtful water; if you are obliged to do so, boil and filter it; if no filter is available, boil.

Sun.—Never expose yourself to a tropical sun without a proper helmet.

Drink.—Never drink beer or spirits in the tropics before the sun goes down. Lemon squashes are more refreshing in the hot time of the day, or well-made barley water, which ensures the water being boiled.

Clothing.—Wear woollen, or silk and wool, sleeping suits at night, and a flannel belt round your stomach. Wear some absorbent material for shirts during the day.

Mosquito Nets.—Always sleep under nets where mosquitoes exist.

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HEAVY MILITARY BRIDGES MADE OF IMPROVISED MATERIALS.*

Extracts from an Article by LIEUT.-COLONEL R. SCHOTT *in the* SCHWEIZERISCHE ZEITSCHRIFT FÜR ARTILLERIE UND GENIE, *December*, 1904.

MODERN warfare demands a mobile army. Only such an army, however, can be mobile which receives assistance from its technical troops in overcoming quickly and easily all possible obstacles. The Commander who possesses superior technical appliances and the most skilled Engineers possesses the greater mobility, and, other things being equal, has a great advantage over his adversary. Such technical troops, however, must be numerous in order to cope with the task allotted to them; and it is necessary that, in addition to careful training, they should be provided with the most modern technical appliances. Many foreign armies carry light bridging material with the advanced guard. Such material should be so light that its vehicles can follow an advanced guard anywhere. It should assist the cavalry in crossing large rivers by providing ferries (horses swimming). Further it should be possible to construct with it light foot bridges across small and medium streams, to enable infantry to cross two abreast, horses one at a time, and the lighter military vehicles (unlimbered if necessary) to be run across by hand. Such light constructions should be replaced by full-sized bridges constructed with the heavy equipment as soon as the latter manages to come up. In most cases, however, the technical troops in front, *i.e.*, the sappers, will manage at an earlier stage to construct trestle bridges with improvised material.

In rivers with soft bottoms, where trestles would quickly sink in, or in rivers with very rapid currents, where the supports would be scoured out, also in cases where, during the summer, strong and unexpected floods are possible, a trestle bridge will not satisfy the requirements of traffic for any length of time, and it will be necessary to replace it by a pile bridge.

PRELIMINARY CONDITIONS FOR BRIDGING.

Above a certain depth of water and velocity of current it is desirable to have the legs of the trestles shod with iron points; if necessary one shoe

* Communicated by the Chief of the General Staff, W.O., and printed by permission of von Huber & Co., Frauenfeld.

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for each trestle would suffice (*Fig.* 1). These iron shoes, used for the first time by Lieuts. Schrafl and Zuppinger during this year's bridging in Turgi, have proved their value beyond doubt; the trestles are immediately held in position when they touch bottom, while without such shoes they always glide a considerable distance down stream, so long as the erecting carriage is not stationary. With a very rapid current and with a moving river bottom, the trestles have often been moved down stream by the force of the current after they were considered perfectly secure, and

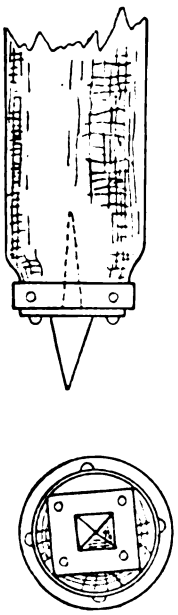

Fig. 1.

even after the bridge had been entirely completed. In such cases it is desirable to construct the bridge so as to form in plan a gentle curve up stream, which stiffens the entire structure on the principle of the arch. If the velocity is great, it is necessary to anchor the trestles into position; in the case of narrow rivers such anchorages can be provided from both shores, but in the case of broad rivers it is necessary to lay them in the bed.

PREPARATIONS FOR BRIDGE CONSTRUCTION.

For round timber it is best to use freshly cut and green pine trees. Old timber is very often worm-eaten, and if it has been lying for some time in the open it is probably partially rotten and defective; it is not possible to make reliable structures with it. Green timber is also more elastic and stronger. For bridges constructed in a strong current and with water of a considerable depth, it is absolutely essential for trestle bridging to employ green timber owing to its considerable specific gravity; dry timber is too buoyant and will not sink to the bottom. The bridge Commander will have to make out a list of timber required, and he will be well advised to provide some spare material (say 10%) for all parts of the

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bridge. Where it is not possible to take a careful cross section of the river, it is desirable to provide strong road-bearers for the last span, capable of spanning 8 m. (26 ft.). Instead of 5 road-bearers 7 or even 9 may be employed, thereby saving an extra support, which is often difficult to get into position. If a spare trestle has been provided, for which cross bracing has been prepared but not fixed, it is possible to cut off the legs to the requisite length, and to fix the cross bracing in a very short time (say 10 minutes). Such a trestle must be adapted to the greatest depth of water, so that it will be available at any point required. Besides this it is necessary to provide spare road-bearers for one span of the roadway. Some spare transoms should also be available.

A careful cross section and a carefully prepared project immensely facilitate the execution of the work. A mistake that is frequently made is to take a cross section only within the breadth of the waterway, and to measure vertical ordinates only at the probable positions of the supports. This is insufficient. Firstly it is necessary to include the two shore approaches in the cross section. Secondly it is necessary to measure the bed of the river, especially if it is irregular, at points intermediate between the supports. This is generally necessary near the shore. With such careful preparation of the cross section it is possible to avoid placing trestles on a steeply falling bottom, or in positions where one leg has to be much longer than the other.

For taking the cross section it is usual to use a cord or tracing line on which the normal spans are marked off. I have often noticed that in fixing these marks the cord is laid loosely on the ground. But it should be borne in mind that there is a difference in length between a slack cord and the same tightly stretched. The spans should, if possible, be marked off on the line when in position, but if that is not possible the marks should be made on the line when tightly stretched. The spans in execution never turn out to be of exactly the same length as assumed in the design. If the river is a broad one, say 100 ft. and upwards, the bridge Commander should first of all see to the construction of an erecting carriage (*Fig.* 5), for which a very solid two-wheeled under-frame from a cart should be obtained. It is, however, necessary to avoid the worn-out carts that peasants frequently possess; the vehicles of sapper transport, which are on springs, cannot be used for this purpose either. Four well-trained carpenters with four assistants can fit up a carriage in about two hours. The following materials are required:—

2 saddle beams, preferably squared, 3·6 ft. long and 5 × 6 inches in section.
2 longitudinal beams about 43 ft. long and 7 to 9 inches in diameter.
1 lever for prolongation, 23 ft. long and 5 inches in diameter.
Sundry small spars.
1 anchor rope.
30 lashings.
10 dog-spikes.
5½ lbs. nails.
1 strong two-wheeled under-frame.

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The carriage, when fully equipped, weighs about 15 to 20 cwt.

The longitudinal poles should project towards the front a distance of L plus 5 ft., where L is the greatest span to be bridged.

The two-wheeled under-frame of the carriage should be capable of bearing the following loads :—

Dead weight of carriage equipment, 20 cwt.
A trestle, weighing as a maximum 12 cwt.
The men of the carriage squad who act as a counter-weight, 23 cwt.
Total, 55 cwt.

In order to be able to withstand sudden blows and jars during erection, a certain margin should be allowed, so that the total carrying power of the carriage should be at least 69 cwt.

Insufficient attention is frequently given to fixing the shore transom, ignoring the fact that the total horizontal pressure of the bridge must be taken by the shore transom, until the road-bearers are connected with the opposite shore. I have seen large temporary bridges over the Ergolz at Liestal collapse like a house of cards when the shore transom had given way. It is generally advisable to employ a very long and strong piece of timber as a shore transom, and if necessary to anchor it strongly towards the land side by means of iron wires, etc.; it should be sunk into the ground. By this means a ramp is avoided, and the jolts against the end board, produced by approaching vehicles, can be entirely prevented. In front of the bridge it is desirable, wherever the approach is not on perfectly hard ground, to provide brushwood foundations with road metalling on the top, in order to avoid deep ruts in front of the bridge.

Where it is difficult to secure the shore transom it is desirable to provide one or more supports on the near shore consisting of pile piers, which should be thoroughly braced both to each other and to the shore transom. It is thus possible to give the bridge considerable strength. These piles are often connected by double transoms like trestles; but it is simpler to cut off the piles at the top to a uniform height, and to nail thereon a log, which should also be securely spiked to the piles. The piles can be driven either by means of heavy mauls of wood or iron, or by a monkey, weighing about 1 cwt., which can best be made of a block of hard wood. This block should have an auger hole, about 1 inch in diameter, bored lengthways through the centre; it should be provided with iron rings top and bottom, and also with four or six side handles, which can be made of round iron dog-spikes, or of ordinary dog-spikes wrapped round with string. If the river bed consists of coarse gravel, the piles should be provided with iron shoes.

Such structures should only be provided on the near shore, as they take much time to make, unless it is possible to prepare them during preliminary preparations on both banks simultaneously. Whenever possible the bridge engineer should attempt to arrange for a normal type of construction on the far shore, if he desires to complete the bridge as rapidly and as smartly as possible. If it should be impossible owing to

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insufficient height to provide an ordinary trestle for the last support, a special framed trestle, resting on a ground sleeper, should be made, or a sleeper crib consisting of two or three layers may be prepared beforehand, ready nailed and spiked.

The bridge trestle (*Fig.* 2), which it is now proposed to lay down as a

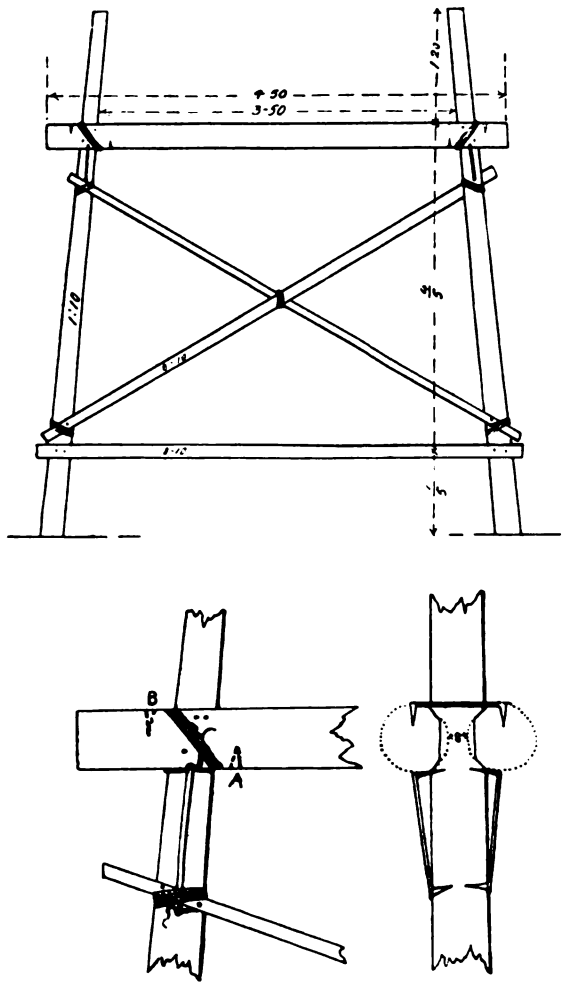

Fig. 2.

type in the new regulations, was found to be very suitable and durable during the recent large bridging operations.

Formerly it was usual to secure the transoms by bolts, which is rather a tedious and slow process. Nails and lashings by themselves are insufficient with stout timbers; if the bridge is much used, and if the weather changes frequently from wet to fine, the lashings are bound to get slack. A very secure connection between the transoms and the

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legs is the fundamental condition for good trestle construction. In place of bolts it is possible to use four dog spikes, which can be driven into the transoms flush with the wood, as shown at A and B. It is best for this purpose to use short dogs not exceeding 14 inches in length, the spikes of which can be driven entirely into the wood. In order to prevent transoms from splitting, it is desirable not to drive the spikes at the extreme end of the transoms; it is better to make them break-joint and to fix the lower ones first and inside the legs, the upper ones subsequently and outside.

All other joints on the trestle are nailed and lashed. It is desirable to remove the bark at all joints where timber comes to bear against timber.

On a bad foundation in water with a moderate current, the legs of trestles are provided with bearing plates (*Fig.* 3). To employ dog-spikes

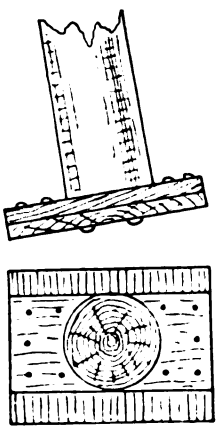

Fig. 3.

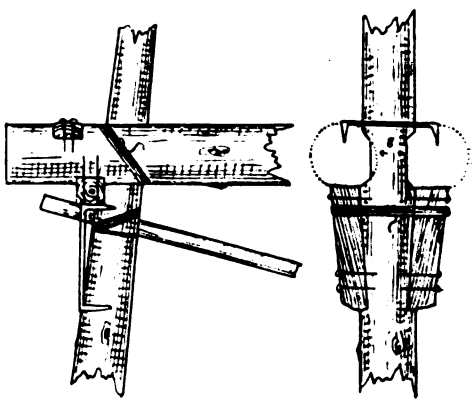

Fig. 4.

as bearers is altogether unsound; I should employ them principally for connecting the transoms together, and should use a different means for transferring the load from transom to leg. The old Schöne's trestle, as used by us 20 years ago, employed only two spikes, which were driven below the bearing blocks (*Fig.* 4). If such a bearing block (best made of hard-wood) is carefully fitted and nailed to the legs and transoms, a very strong joint is made, which is especially to be recommended for low trestles, where dog-spikes fixed at the sides make it difficult to secure the diagonals. In order to tie the transoms well together a smaller hard-wood block may be housed into them (perhaps by dovetailing) and secured by nails. It is, however, also possible to employ the Swedish system (*Fig.* 4), which does without any spikes, and uses hard-wood brackets nailed underneath the transoms; in this case, however, it is desirable to use especially strong legs, so that notches can be cut into them sufficiently deep to provide a level bearing for the brackets.

Strong door or window hinges, which can be found in every house and every shed, can be employed as a substitute for dog-spikes. Straight straps from large gates can be used for tying the transoms together by

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bending them round the latter and securing them with nails; while the gates themselves can be used for forming the roadway.

The mistake is frequently made of not lashing the two transoms so as to have their top surfaces at the same level, and this brings the whole load on to one transom. If a bridge slopes towards one bank it is necessary to fix the transoms to the legs to suit this condition.

The roadway, from excessive caution, is often not placed sufficiently high. By giving some extra height the trestles are not made much heavier, more play in construction is thereby obtained, and with steep river banks high bridges are absolutely necessary in order to avoid deep approach cuttings.

When a trestle is found to be much too low and the current is very strong, making an alteration in the position of transoms too risky, it is possible to adopt an expedient which was used in the construction of a bridge over the Landquart, where it was impossible to prepare a cross section owing to the torrent. The outer road-bearers were placed one after the other somewhat nearer the centre than usual, and were there spiked; across these road-bearers new transoms were placed, and on these the real road-bearers were secured. It is also possible to secure short cross pieces between the lower old transoms and the upper new ones; then, when the centre road-bearers have been permanently secured, the outer ones can be released and refixed in the upper position; such cross pieces, which are best made of square section, should be prepared beforehand in various sizes, and set apart with the spare materials.

The road-bearers are provided at each end with a hard-wood trenail, at least 1½ inch thick and 6 inches long. For the trenails it is best to use very tough and green hard wood, like white or black thorn, hornbeam, oak, maple, etc.; alder, willow, pine will not do, because they are not sufficiently tough. Dry wood is brittle and is also not to be recommended.

As regards the roadway, at least one-third of the boards should be provided with notched ends, and it would be better to provide such notches to half the boards, so that there should be no delay or difficulty in rack lashing.

The ribands should be of equal length. Each span should be provided with independent rack lashing. It is not desirable to allow a riband to overlap its own span.

In cases where narrow paths lying close along the bank of a river lead up to the bridge, it is best to make the first span of double width. The structure thus gets a firm support on the shore, and the approach is comfortable. If the approach road is very narrow indeed, and is situated at the foot of steep and high banks, I generally arrange to have the first two spans made of double width.

CONSTRUCTION.

We shall only deal with the construction of large bridges, for which at least one company of sappers should be available. With such bridges it is usual to commence launching only when preliminary work has been sufficiently advanced to favour the prospect of the bridge being completed without a hitch.

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For normal construction with the erecting carriage (see *Fig.* 5 and *Photos*), parties should be told off as follows:—

1 boat	party ...	1	N.C.O. and	2 men per boat.
1 constructing	,, ...	1	,,	,, 6 ,,
1 carriage	,, ...	1	,,	,, 20 to 30 men (usually the former).
1 carrying	,, ...	1	,,	,, 10 to 16 ,, ,, ,, ,,
1 road-bearer	,, ...	1	,,	,, 10 ,,
2 chess carrying	,, ...	2	,,	,, 8 ,,
1 chess laying	,, ...	1	,,	,, 2 ,,
1 rack lashing	,, ...	1	,,	,, 8 ,,

Store detachments with the rest of the company.

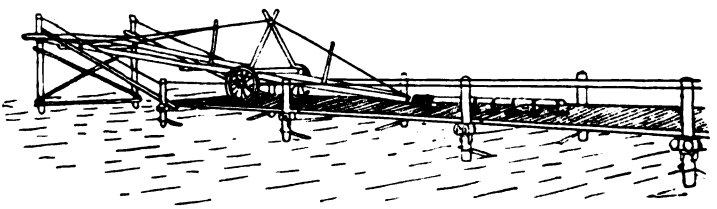

Fig. 5.

The four company officers undertake the following duties respectively. The Captain, who is generally the bridge commander, supervises the whole work. The Erecting Officer directs erection at the head of the bridge; the handling of the erecting carriage, the placing in position of trestles and road-bearers, and of the roadway itself. The Officer in rear controls the movements of the various squads, so that there may never be an excessive number of men on the bridge; he supervises the rack lashing and the fixing of hand-rails. The Depôt Officer supervises all work on the storage ground; above all he should take care that, by careful selection and sorting, all materials are employed to the best advantage; the strongest and heaviest materials should be reserved for spans in mid-stream.

For the Constructing Detachment carpenters who are specially skilled, smart, and willing should be selected; they assist the Carrying Detachment in getting the trestle over the last pier. The near transom of the trestle last brought up is placed on the legs of the last fixed trestle. The first road-bearers to arrive are the two outer ones, which are provisionally spiked and lashed to the near transom; the same transom is also attached loosely by means of lashings to the long poles of the erecting carriage. Two lashings joined together are attached to each leg of the trestle near the top, so that the position of the trestle can be regulated with them; these lashings can be used for a temporary hand-railing after the trestle has been pushed out. As soon as the trestle is in position, two men provided with hand-axes and dog-spikes go across the road-bearers on to it, and ascertain whether the pier is vertical. If this is not the case, the trestle must be raised and again lowered until it is in the correct position. After this the carriage is unlashed, the outer road-bearers are unlashed and spiked securely, and the remaining road-bearers are also fixed.

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The Carriage Detachment works the erecting carriage. The position of the commander is on the carriage itself, for facility of supervision and so that all men can see his signals. In a strong current it is necessary to push the trestles as far up-stream as the play of the outer road-bearers, which are jammed in at the back, will allow, and then the trestle can be lowered with a jerk. In order to be able to raise the trestle again, if necessary, the tail end of the carriage should be provided with 4 or 6 lashings. On each side, near the wheels, one man is posted ready to scotch up the carriage by means of a hand-axe. The carriage is taken off the bridge as soon as the trestle is in position.

The Carrying Detachment has to bring up new trestles, legs in front, suspending the trestles as before described, with the aid of the Constructing Detachment, above and in front of the outermost pier.

The Chess Layers should exchange sides from time to time, which is best done at each new span. This prevents planks being placed crookedly on the bridge; this is especially likely to happen on a long bridge, because the planks are never pushed home with equal force by two different men.

In constructing the bridge the most important thing to attend to is that all piers are perfectly vertical. I attach much less importance to a pretty and straight bridge than to a substantial and strong one. In a strong current it is very difficult to maintain the correct alignment for the bridge; in such cases it is always desirable to try and point up-stream at the commencement; then the bridge of its own accord will gradually attain a correct alignment.

BRIDGE CONSTRUCTION DURING RECENT SAPPER TRAININGS.

The Sapper Recruits, amongst other bridging exercises during their period of training, constructed a bridge across the Aare at Brugg with improvised material only. The Aare has a breadth of 130 m. (430 ft.) at this spot; during the exercise the mean depth of water was 6½ ft., the maximum depth 8½ ft., with a velocity of 8½ to 10 ft.

In mid-stream, where the velocity was very great and the depth measured more than 6½ ft., three supports on river boats were allowed for. With so strong a current and with such depth of water it was not thought possible to place trestles in position; experience has since proved that this view was erroneous.

An opening of 82 ft. was left in the centre. In order to close this opening 3 floating supports, consisting of coupled fishing-boats, were prepared, anchored, and floated into position by pontoon troops, who happened to be doing their refreshing course.

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REVIEWS.

AN AUXILIARY PORT FOR LONDON.

UNDER this title P. S. King & Son (Orchard House, Westminster) are publishing a series of pamphlets on the subject—"Can London spend her money to better purpose?" The first Paper is by 'Innovator,' and deals with "The River: Its Enlochment." Other Papers are to follow on:—Sewage Disposal, Improvement of Metropolitan Traffic, and a System for Supply Delivery in the Metropolis.

Paper I. deals with a subject that was discussed in this *Journal* in the early part of the year under the heading of "The Future of London." 'Innovator' sees many disadvantages in the proposals both for extensive dredging of the Thames channel and for constructing a barrage at Gravesend. He proposes to erect a barrage across the *estuary*, about 2 miles above Southend, thus creating a huge lake; and he calls his scheme the 'enlochment' of the river, in contradistinction to its 'canalization' by a barrage higher up. The Southend barrage would transform the whole river up to Kew into a vast lake, with practically permanent high water; the area of the harbour proper being about 10 square miles, and the depth of the lake varying from 20 to 30 feet at London Bridge to 50 feet at the barrage, which would be 2 miles long. The two sides of the barrage would provide great lengths of quayage, and the loch would become a deep sea port, capable of accommodating the largest vessels at all times. The lake would be kept clean by the water contents being changed in the course of every four tides. Across the barrage would be a broad thoroughfare between the two shores of the river.

In connection with his proposal the author suggests, in addition to minor schemes:—(1) The generation of electricity by water power, firstly for use in the port itself and secondly for distribution to the Metropolis; (2) an electric road from the port straight through London to Brentford, connecting with all the existing railway systems that converge into London; (3) the utilization of Canvey Island and the adjacent marshes as a huge Farm for the Sewage of the Metropolis; (4) the reclamation of some 5 miles of foreshore at Southend; and (5) the erection, opposite Canvey Island, of "Silverstrand," a 'City on the Sea' or 'Venice in London.'

'Innovator' enumerates the various advantages which his scheme possesses over others already proposed, and deals in general terms with its cost and the revenues likely to be derived; but he does not enter into engineering details.

A. T. MOORE.

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WRITING FOR PUBLICATION: THREE BOOKS FOR THE ASSISTANCE OF AUTHORS.

(1). *Author and Printer*, by F. Howard Collins. (5s.; Henry Frowde). This is a combined spelling, pronouncing, and explanatory dictionary, which, though actually arranged in one alphabetical sequence, may be divided, for the purposes of review, into six main portions:—

(*a*). Ordinary words, place names, and proper names, which provide the most common pitfalls for the writer:—*e.g.*, the use of 'who' and 'which'; the spelling of 'connexion' and 'affection'; the pronunciation of 'Marjoribanks'; the spelling of 'Mohammed' and 'Lhasa.'

(*b*). Abbreviations:—*e.g.*, 'M. Inst. C.E.'; 'M.J.I.'

(*c*). Celebrities:—*e.g.*, 'Mozart (W. A.), 1756-91, Austrian composer'; 'Sir Sydney Smith, 1771—1845, wit.'

(*d*). Foreign words and idioms:—*e.g.*, 'cui bono'; 'diner par cœur'; 'giaour'; 'nirvana'; 'rilievo.'

(*e*). Technical words used in the printing trade:—*e.g.*, 'em'; 'forme'; 'pica'; '12mo.'

(*f*). Hints for authors under:—'capitals, use of'; 'italics, use of'; 'paper, sizes of'; 'proof correction marks'; 'punctuation'; 'type, sizes of.'

The information under the first four heads is of great value to everyone. But that under the two last is useful principally to the author. From the author's point of view, therefore, the book would be more useful if the technical terms in printing, and the information and hints particularly helpful to a writer, were separated from the rest.

Mr. Collins does not attempt to differentiate between 'shall' and 'will.' This is probably a case of discretion being the better part of valour, as there is no rule that is of any practical utility. Indeed—so the reviewer has been told—one of the leading prose stylists of the present day has to have his manuscripts read by an Englishman in order to ensure these words being correctly used. In this connection book (3) below quotes the rhyme:—

> In the first person simply *shall* foretells;
> In *will* a threat or else a promise dwells.
> *Shall* in the second and the third does threat;
> *Will* simply then foretells the future feat.

The book may be looked upon as a standard guide, as the author submitted proofs (sometimes more than once) to some fifty experts, besides receiving assistance from many others, and consulted all the standard dictionaries and literature on the subject; and the result has been approved by the Master Printers' Associations of London, Edinburgh

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and Belfast, and by the Executive Committee of the London Association of Correctors of the Press.

In his preface, Mr. Collins quotes a distinguished etymologist:—"There is a tradition . . . that a crabbed writing is given to a clever compositor, and therefore one ought to write badly. The gross selfishness of this is simply shameful. . . . A man who is a gentleman will make his copy legible for the express purpose of enabling the compositor to earn more wages (and to save his eyesight)." The author himself adds "Even for his own sake an author should write legibly, for bad copy invariably results in increased cost and in delay, besides greatly multiplying the chances of error. . . . A great deal of delay, trouble, and expense, to all concerned in the making of a book, may be saved if the author will have his manuscript revised by a proof reader *before* it is given to the compositor to be set up in type. . . . One firm of printers, having given this plan a trial, found the result so successful, that now *every* manuscript sent to them is revised by their proof-readers before it is composed."

Altogether a vast deal of information is included in 407 pages, $7\frac{1}{2}'' \times 5''$; and the highest compliment that can be paid to the book is to say that every writer should have it on his table.

(2). *Punctuation: Its Principles and Practice*, by T. F. Husband and M. F. A. Husband. (2s 6d.; Routledge).

The first part of this little work is historical; the second deals serially with the various marks of punctuation, giving some very lucid explanations of their proper use and some typical examples. The ordinary person would probably learn all that is necessary from the seven pages devoted to this subject in the first named book (1).

The work under reference contains one piece of information which may be news to most of us. "In legal documents, where clearness of reference is the first essential, punctuation-marks are systematically omitted precisely because this omission necessitates a constructional expression the meaning of which cannot be mistaken." It is comforting to know that the said absence of stops has its origin in so praiseworthy an object; whether that object is ever achieved is another story. Most people, who have had the misfortune to be involved in trying to detect the meaning of a legal document, have assumed that legal writers systematically omitted stops in order that their successors in the profession of law might earn their living in disputing over the real intentions of the deceased signatories.

The first rule is probably the most important one—Never put in a superfluous stop; so perhaps the lawyers are right after all.

(3). *Composition and Style*, edited by R. D. Blackman. (5s. Deacon & Co.).

As this is the fifteenth edition it may be presumed that the book meets an expressed want; but the greater part of it is useful only to persons deliberately taking up letters as a profession.

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The greater part deals with 'Structure of Sentences'; figurative language, such as 'Apostrophe,' 'Hyperbole,' and 'Metaphor'; and the various styles, *e.g.*, 'Concise' and 'Diffuse,' 'Plain' and 'Florid.' It also includes critical examinations of passages from Addison and Swift; and an illustration of the 'Progress of English Style' in the form of extracts from the writings of the best prose authors from Ascham (d. 1568) to Ruskin (d. 1900). The book is somewhat overloaded with examples, and is written in the 'diffuse style' which it condemns; curiously enough too, the system of punctuation is at variance with the commonsense principles adopted in the two books referred to above, (1) and (2).

The earlier pages, however, give some useful hints on grammatical errors, and also on style in general.

"To know what you would say and to say it with freedom and with individuality is the great point." "Practised writers make up their minds beforehand, both as to what they mean to say, and as to how they ought to say it." "An author's meaning ought always to be obvious, even to the most careless and inattentive reader. . . . We must study, not only that every reader may understand us, but that it shall be impossible for him to misunderstand us." The principal qualification for a good style is Perspicuity, the ingredients of which are Purity, Propriety and Precision; Purity is defined as "the use of such words, and such constructions as belong to the language which we write," and Propriety as "the selection of such words, as the best and most established usage has appropriated to those ideas which we employ them to express." Dr. Armstrong's idea of the best language is quoted as "the shortest, clearest, and easiest way of expressing one's thoughts, by the most harmonious arrangement of the best words, both for meaning and sound. The best language is strong and expressive, without stiffness or affectation; short and concise, without being either obscure or ambiguous; and easy, and flowing, and disengaged, without one undetermined or superfluous word." As regards Precision, we think it was von Moltke who defined a well written order as one that did not contain a single word the omission of which would neither affect its sufficiency nor vitiate its meaning.

The quality of Precision is of course largely controlled by the proper ordering of words and the intelligent use of punctuation, to both of which much care should be devoted. Our old friend *Punch* frequently gives extracts from other publications, especially from their advertisement columns, showing the grotesque results that follow from carelessness in these details. Innumerable instances might be quoted of the omission or improper placing of stops. In regard to the even more common fault of neglecting to consider the sequence of words, the reviewer begs leave to quote from the concluding paragraph of a recent book which elsewhere throughout its contents exhibits a perfection of style—"There was a familiar sound of shouts and cab-wheels and omnibuses coming heavily through the open window": not many of us, we trust, are familiar with the entrance of omnibuses, either heavily or otherwise, through the windows of their chambers, but possibly this does occur sometimes during the fogs in London where the book was written, and of course we

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occasionally hear of our own traction engines breaking into houses through area walls. We may also quote two orders issued during the late war in South Africa—"All rubbish in camp will be collected every evening and burnt under an officer"—"No one may sleep outside the blockhouse except the sentry": small wonder that blockhouses were now and then surprised, and that officers became scarce towards the end of the campaign.

With respect to Perspicuity in general we are told that Tennyson and Macauley re-wrote their pages over and over again until they attained the gracefulness and dignity which is commonly supposed to have been merely the attributes of peculiarly facile pens. Artists of the brush also possess that 'infinite capacity for taking pains' which usually passes under the name of 'genius'; it is said, for instance, that Phil May's wonderfully articulate sketches were really produced by pruning and trimming more or less elaborate drawings until not one superfluous line remained.

An Addendum to the book, entitled "Printing and Publishing" and apparently included for the first time, contains much information of interest, especially to anyone who has to see his own productions through the press. It deals with such subjects as:—Manuscripts; Proof Correcting; Size of Paper and Type; Binding; Copyright.

The best paper for Manuscripts is 'foolscap quarto,' 6¾" × 8¾"; anything much larger is inconvenient for the compositor to handle, whilst smaller sheets are liable to get mixed up or go astray. The best colour is white. A margin should be left, and any emendations should be made thereon, as they are easier to read there than when written over altered words. The handwriting should be distinct, special care being taken with capital letters and with all proper names and technical terms; and it should be readable with certainty, for all interlineations, erasures, etc., add to the work of the compositor and usually also to the cost of printing. Each sheet should be numbered, and headed with the title or part of the title [for the whole of a MS. is not necessarily given out to one compositor; in journalistic work, in fact, it is most often distributed to several]; and the left-hand top corner should be left free for a fastener. Particular attention should be paid to punctuation; the printer cannot be depended upon to supply the proper stops in place of indefinite dots and dashes; the latter often result in disaster to the author's sentences and needless expense in corrections. The lengths of the lines should be uniform; and it might have been added that new paragraphs should be clearly defined, for prose written as if it were blank verse is a fruitful source of error in printing.

The printer follows the 'copy.' If he sets the copy right where it is obviously wrong, the author has to pay. The author has also to pay for all corrections made by him in the proof, except those due to the printer's unwarrantable departure from the copy. A carefully prepared MS. therefore means a saving in expense. Inexperienced writers are to be warned that an apparently small correction to a proof may involve a considerable re-arrangement of type; for instance, making a new paragraph necessitates shifting words from one line to the next to the end of

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the original paragraph. This section of the book contains a sample of a first proof corrected for the press, showing all the conventional signs in use, and is worthy of study.

As regards Paper, the book refers to 'laid' and 'wove,' the former being distinguished by linear marks down and across the sheet; but these terms are really only applicable to 'writing paper.' In the trade all paper used for printing books is classed as 'printing paper.' The latter is distinguished by weight, and the same quality of paper can be manufactured in various weights as well as in various sizes; paper of other than standard quality, size, and weight has to be manufactured specially, an expensive procedure unless a large quantity is required. Printing paper should be tough, of good colour, properly sized, and (for ornamental printing) well glazed. It is sold in reams containing 516 sheets. This *Journal* is printed on royal octavo paper, 30 lbs. to the ream.

The size of a book depends on the size of the sheets of paper on which it is printed and on the number of times each sheet is subsequently folded. The papers most commonly used are:—foolscap ($13\frac{1}{2}'' \times 17''$), royal ($20'' \times 25''$), demy ($17\frac{1}{2}'' \times 22\frac{1}{2}''$), and crown ($15'' \times 20''$). The original sheet is usually folded once in the first instance, making 2 equal leaves or 4 pages, called folio size; a foolscap folio page is thus $8\frac{1}{2}'' \times 13\frac{1}{2}''$, prior to the trimming of edges before binding. Subsequent folds always divide the paper again into two equal parts; a sheet folded three times thus makes 8 leaves or 16 pages, called octavo (8vo.); accordingly a royal octavo page is $6\frac{1}{4}'' \times 10''$, and a demy octavo $5\frac{5}{8}'' \times 8\frac{3}{4}''$. Sometimes the original full sheet is folded twice in the first instance, being divided into three equal parts; two further folds into two equal parts produce 12 leaves or 24 pages, called duodecimo (12mo.); a crown 12mo. page is therefore $3\frac{3}{4}'' \times 6\frac{2}{3}''$. Diagrams are given showing how the various sizes of sheets are folded to produce various sizes of pages, and how the type is arranged in the 'formes' for printing, so that when the sheets are folded the pages will be in proper sequence.

Samples are given of the various sizes of Type. The most common are:—'small pica' [used for the main articles in the *R.E. Journal*]; 'long primer' [used for translations in this *Journal*]; 'brevier' [used for the Domestic Occurrences in the *Supplement*]; and 'nonpareil' [used in the *Monthly List*]. The lines are either set solid or spaced with one or more leads [the main articles in this *Journal* are 'single-leaded'].

The information as to Binding is somewhat scanty, and 'casing' and 'binding' are not differentiated; in the former the book is only attached to the cover by book-binders' cloth, glued on; in the latter the back of the book is sewn to short cords, the ends of which are opened out and beaten into the cover. The former method is more generally employed; the latter more durable, but more expensive, one can usually be distinguished by ribs on the back of the cover. Books are usually cased in paper or cloth, and bound in leather; a half bound book has leather backs and corners with paper or cloth sides, but the method of binding is the same as if it were full-bound.

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"Copyright is created by statute. . . . In a book it lasts either for 42 years from the date of first publication, or for the author's life and seven years after his death, according as the one or the other period is the longer. It is valid throughout all the British dominions."

"A book may or may not be registered at Stationers' Hall. In either case the copyright remains unaffected. But it must be registered there before legal proceedings can be taken for the protection of the copyright."

A. T. MOORE.

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NOTICES OF MAGAZINES.

NATURE.

August, 1905.

WARSHIP DESIGN (*p.* 320).—Sir P. Watts, at the Institute of Naval Architects, in tracing the progress made in the design of warships since Nelson fought at Trafalgar, compared the weights apportioned to the different elements in a battleship of 1805 and one of the present day. The old ship of 74 guns had 20 per cent. of the total displacement awarded to general equipment as against 4 per cent. for the 1905 battleship. Armament in 1805 was 10 per cent. of the displacement; in the present day 19 per cent. The propelling arrangements are somewhat in the nature of a surprise, masts, sails, and rigging absorbing 8·5 per cent., and modern steam machinery only 10·5 per cent. of the displacement. The 74-gun ship required 6·5 per cent. for ballast to give stability under sail, while the 1905 ship takes 5·5 per cent. only for coal. Armour takes 26 per cent. and 35 per cent. for the steel hull of the modern ironclad, total for both 61 per cent., whilst the old wooden hull absorbed 55 per cent. of the total tonnage. The construction of the "wooden walls" was more massive than was needed for ordinary purposes, and a good part of the 55 per cent. might be set down as wooden armour.

LIQUID AIR (*p.* 353) was stated, in some company schemes, as a source of power to eclipse and replace steam and electricity. As an artificial refrigerator it was to banish ice, ammonia, sulphur dioxide, and carbonic acid. In surgery it was soon to be the only anæsthetic, antiseptic, and caustic employed. In medicine it was to cure consumption and many other diseases. One of the most promising applications proposed for liquid air has been the manufacture of oxygen from air by liquefying it and letting the nitrogen boil away before the oxygen, separating them by distillation, but practical success has not yet been achieved in this or in the other schemes above-mentioned. The liquid oxygen or air rich in oxygen obtained by distillation from liquid air if mixed with cotton wool makes an explosive, and has been tried by Austrian engineers in tunnelling under the Alps, but was found to be too cumbrous in application and the results too uncertain in practice.

The most pronounced successes of liquid air have been in connection with scientific research; by being frozen in liquid air the bacilli of typhoid become brittle enough for trituration in a mortar, and then by centrifugalisation the nitra-cellular poison can be separated, and then by the methods of Pasteur an anti-typhoid serum prepared, which promises to be of real value. Also, by the liquid air process, krypton, xenon, and neon have been discovered, and the emanation of radium and thorium proved to be condensable and vaporisable, and helium shown to be produced from radium emanations. Finally, it was by an extension of the same process that hydrogen was liquefied.

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RESEARCHES ON EXPLOSIVES, by Sir A. Noble (*p.* 359).—Experiments made on erosion with (1) cordite, (2) cordite M.D., (3) a tubular nitro-cellulose, and (4) other explosives have satisfied the author that the amount of absolute erosion is governed entirely by the heat developed by the explosive.

PROFESSOR DARWIN'S inaugural address, as President of the British Association at Cape Town, deals with the fascinating idea that matter of all kinds has a common substratum. It has been shown that the atom consists of a large number of component parts, and that the simplest of all atoms, namely, that of hydrogen, consists of about 800, while the number of parts in the atom of the denser metals must be counted by tens of thousands. These separate parts of the atom have been called corpuscles or electrons, and are particles of negative electricity, moving with high speed, comparable to the velocity of light, and restrained from breaking up the atom by the positive charge of the shell of the atom inside which they are revolving.

Lord Kelvin has shown that if a drop of water were magnified to the size of the earth, the molecules of water would be the size of a small cricket ball. Each molecule contains three atoms, two being of hydrogen and one of oxygen, the atoms bearing to the molecule some such proportion as the molecule to the drop of water referred to. Finally, the corpuscles may stand to the atom in a similar scale of magnitude.

Communities of atoms are called chemical combinations, and we know that they possess every degree of stability. The existence of some of them is so precarious that the chemist can barely retain them for a moment; others are so stubborn that he can hardly break them up. The more persistent or more stable combinations succeed in their struggle for life and are found in vast quantities, as in the case of common salt and of the combinations of silicon. But no one has ever found a mine of guncotton, because it has so slight a power of resistance. Stability is a property of relationship to surrounding conditions: thus salt is adapted to the struggle for existence on the earth, but it cannot withstand the severer conditions which exist on the sun.

GOLD IN SEA WATER is stated by Mr. Beilby, in his chemical address to the British Association, to exist in the sea in the proportion of about 1 grain per ton of water. No drop, however small it may be, can be removed from the ocean which will not contain many millions of gold molecules! From this molecular point of view our ships literally float on a gilded ocean! From time to time adventurers have tried to obtain this gold from the sea, but cyaniding experts, whose business it is to extract gold from dilute solutions, find that it does not pay to carry this extraction beyond a concentration of 2 to 3 grains per ton even, when the solution is ready at hand. If ever the Transvaal gold mines are shut up, it will *not* be owing to the competition of the gold resources of the ocean.

VALUE OF π.—A French mathematician has composed a quatrain of 31 words which sets out the value of π to 30 places of decimals. Each

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word contains the number of letters corresponding with the successive numbers in the numerical expression 3·14159265358979323846264338327 9.

3 1 4 1 5 9 2 6 5 3 5
Que j aime a faire apprendre un nombre utile aux sages
8 9 7 9
Immortel Archimède, artiste ingénieur !
3 2 3 8 4 6 2 6
Qui de ton jugement peut priser la valeur ?
4 3 3 8 3 2 7 9
Pour moi ton problème eut de pareils avantages.

GEOLOGY (*p.* 413).—Prof. Miers, in his opening address to the British Association at Cape Town, spoke mainly from the view, not of the geologist or chemist but of the crystallographer, to whom the birth and growth of crystals are a study in themselves. Whether we watch with the microscope a tiny crystal growing from a drop of solution, or contemplate with the imagination the steps by which the fiery lavas of past geological periods sank to rest and crystallised, we view the same process; it is the transformation of liquid into crystal—not necessarily into a solid, for recent researches show that there is no dividing line between liquid and solid; a plastic body may flow; a solid glass is only a supercooled liquid. The real distinction is between crystalline and non-crystalline material, and there is reason to believe that some crystals are liquid without ceasing to be crystals.

STERILISATION OF WATER IN THE FIELD (*p.* 431).—In the Spanish-American War it was proved that infected water was not an important factor in the spread of typhoid fever. The other agents concerned in the dissemination of this disease are dust and flies, blowing or carrying infection from infected latrines, the result of heat, fatigue, and bad food rendering the troops more vulnerable. It cannot be doubted, however, that a pure water supply would lessen the incidence of typhoid fever and dysentery, and probably quite prevent cholera. The Japanese, in the present campaign, sent on ahead of their troops a corps of doctors to select the camping ground and survey the water supply, with great success in preventing disease. Sterilisation of water by heat to about 170° F. is satisfactory, but important considerations are the weight of the machinery and fuel necessary to be carried. Chemical germicides such as bisulphite of soda can be put up in tablets, and in quantities of 15 grains to the pint the typhoid bacillus will perish, whilst the bisulphite imparts little or no taste to the water and is quite harmless.

W. E. WARRAND.

REVUE D'HISTOIRE.

August, 1905.

THE SURPRISE OF THE BRIDGES AT VIENNA IN 1805.—The *ruse* by which Murat gained possession of the bridges over the Danube has been described by Thiers and others, but their accounts are amplified and corrected here from papers in the French archives and from Angeli's

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narrative, "Ulm und Austerlitz." The municipality of Vienna, anxious to save the city, played into Murat's hands; and the Austrian commander, Prince Anersperg, was the more easily taken in because he was himself hoping to gain time by negotiation, and wished to have an interview with Murat. Bertrand, who was the first man allowed to pass, gave his word of honour (according to the Austrian report) that an armistice had been concluded, and that he had come straight from Napoleon's headquarters to announce it to Prince Anersperg. Lulled by these assurances, the Austrians allowed others to follow him. Murat, with a column of grenadiers, reached the south end of the main bridge, a wooden bridge a quarter of a mile long, which had been prepared for destruction at any moment. Four French officers, including Lannes and Belliard (but not Murat himself, as is commonly said), strolled across it, and persuaded the Austrian captain in charge to turn his guns away from the bridge and let his men pile arms.

"During this time," says Belliard, "the leading platoon moved forward gradually; behind were the sappers and gunners, who, screened by this body, threw all the combustibles into the Danube, damped the powder, and cut the fuses, so as to prevent the burning of the part of the bridge which we already occupied. The Austrian officer understood little French and spoke less; he noticed the movement and tried to make us understand that the troops were marching, and that that must not be: we told him they were trying to warm themselves, for it was very cold, by stamping their feet. The column of infantry followed, and in this way three-fourths of the bridge were won. Then the Austrian officer commanding the artillery cried 'Faer! Faer!' The men seized their arms, the guns were turned again on to the bridge, and everything pointed to a disaster. Marshal Lannes laid hold of the commanding officer by the collar on one side, I on the other; we shook him, and shouted loudly, that his men might not hear him, holding him responsible for all the blood he was about to shed."

This delayed the execution of his orders, and immediately afterwards Anersperg arrived with Bertrand. While they discussed the conduct of the officer the French gained complete possession of the bridge.

THE CAMPAIGN OF 1797 ON THE RHINE.—The appointment of Hoche to replace Beurnonville in the command of the army of the Sambre-et-Meuse, and other changes preliminary to the opening of the campaign, form the subject of this section.

THE WAR OF 1870.—*The Army of Chalons.*—On the 23rd and 24th of August Macmahon's army marched towards the north-east. It was short of supplies, and there were already disquieting symptoms of insubordination; officers were insulted and the inhabitants were pillaged. The German armies under the two Crown princes were still moving westward on Chalons. The contingency of Macmahon's going to the help of Bazaine was considered at the German headquarters, but was thought improbable.

E. M. LLOYD.

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CORRESPONDENCE.

THE PREVENTION OF DAMPNESS DUE TO CONDENSATION IN MAGAZINES.

SIR,

The interesting Transcript on the above-named subject, in the September number of the *R.E. Journal*, recalled to my mind an experiment I made some 40 years ago, when quartered in Guernsey.

It appeared that several Boards of Inquiry had been held, resulting in lining the walls with cement, asphalt, etc., under the idea of the wet percolating through them; and, finally, open-batten doors had been fixed to allow of the free circulation of air.

I obtained permission from the C.R.E. (Colonel Hadden) to take in hand a small asphalt-lined magazine, the walls of which were always streaming with water. To prevent the contact of the moisture-laden air, which I knew to be the culprit, with the rapidly-conducting surface of the asphalt, I painted it over with a thick coating of lampblack, as a good non-conductor, with the result that the walls ceased to weep, except where left unpainted. Nothing further, however, was done, in deference I fancy to the tender feelings of the above-mentioned Boards.

Yours truly,

H. C. SEDDON,

The Editor, "R.E. Journal." *Colonel, R.E. (Retired).*

DEAR SIR,

The article on Magazines in the last number of the *Journal* brings back to my mind a question which I propounded to my superior officer many years ago—

"Why do you want to prevent moisture condensing on the walls of a magazine?

This condensation must necessarily reduce the amount of moisture in the air which is in contact with the powder or other stores. If the moisture is on the walls it cannot be in your powder."

I did not get an answer to the question.

I now ask another—

"Would it not be better to encourage as much as possible the condensation on the walls—making, of course, suitable arrangements for carrying away the water without its dripping on the powder cases?"

Yours truly,

E. ROBERT FESTING,

The Editor, "R.E. Journal." *Major-General, R.E. (Retired).*

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RECENT PUBLICATIONS.

A History of the Civil War in the United States of America, 1861–65, by W. Birkbeck Wood, M.A., and Major J. E. Edmonds, R.E., *p.s.c.*, with an introduction by Spenser Wilkinson. (9 × 5½. 12s. 6d. Methuen).

The Development of Strategical Science during the 19th Century, by Lieut.-General von Caemmerer, German Army, translated by Karl von Donat. (8½ × 5½). 7s. 6d. Hugh Rees).

With Togo. The story of seven months' active service under his command, by H. C. Seppings Wright. (9 × 6. 10s. 6d. Hurst & Blackett).

International Law as interpreted during the Russo-Japanese War, by F. E. Smith, M.A., B.C.L., and N. W. Sibley, B.A., LL.M. (10¼ × 6½. 25s. Unwin & W. Clowes).

Wireless Telegraphy and Hertzian Waves, by S. R. Bottone. (7 × 5. 3s. 6d. Whittaker).

Private House Electric Lighting, by F. H. Taylor. (Marshall & Co.).

Repairs: How to Measure and Value them, by George Stephenson. 4th edition. (Batsford).

British Standard Specifications and Tables for Telegraph Materials. (Interim Report of the Engineering Standards Committee). (10s. 6d. Crosby, Lockwood).

Electromagnetische Schwingungen und drahtlose Telegraphie, von Dr. F. Zenneck. (25 mks. Enke, Stuttgart).

The Irrigation Works of India, by R. B. Buckley, C.S.I. 2nd edition. (13 × 10. £2 2s. Spon).

The Motor Year-Book, 1905. (5s. Methuen).

The Lands of the Eastern Caliphate, by G. Le Strange. (15s. Cambridge University Press).

The Far East, by Archibald Little. (7s. 6d. Clarendon Press, Oxford).

The Arab: The Horse of the Future, by Hon. Sir James P. Boucaut, with preface by Sir Walter Gilbey, Bt. (9 × 6. 7s. 6d. Gay & Bird).

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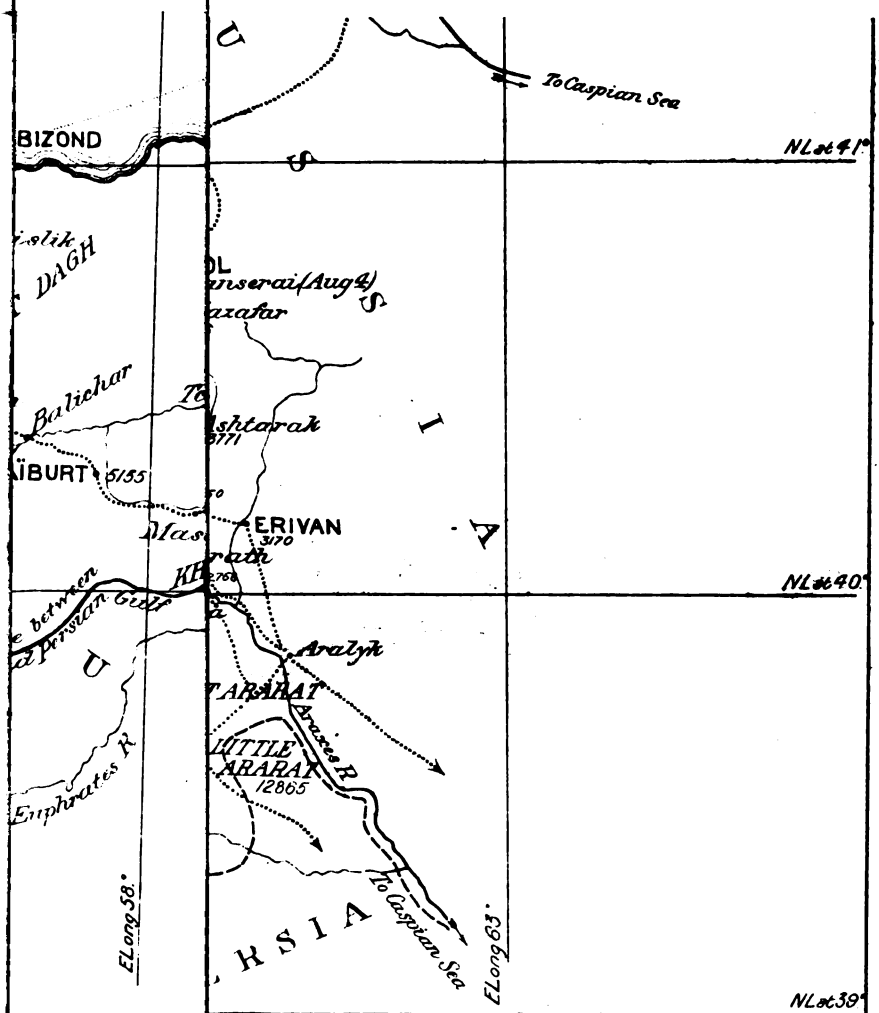

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Militia Literary: G. V. C. Irwin, A. St. J. Wright, M. C. Coote, R. Lechmere.

Woolwich (Dec., 1904): 2nd, F. W. Thicknesse; 7th, C. E. Fane; 24th, C. O'Driscoll Preston. (Two others previously).

Sandhurst (Dec., 1904): 24th, G. de la Poer Beresford; 32nd, H. G. C. Colville; 68th, C. H. Blackburn. (Two others previously).

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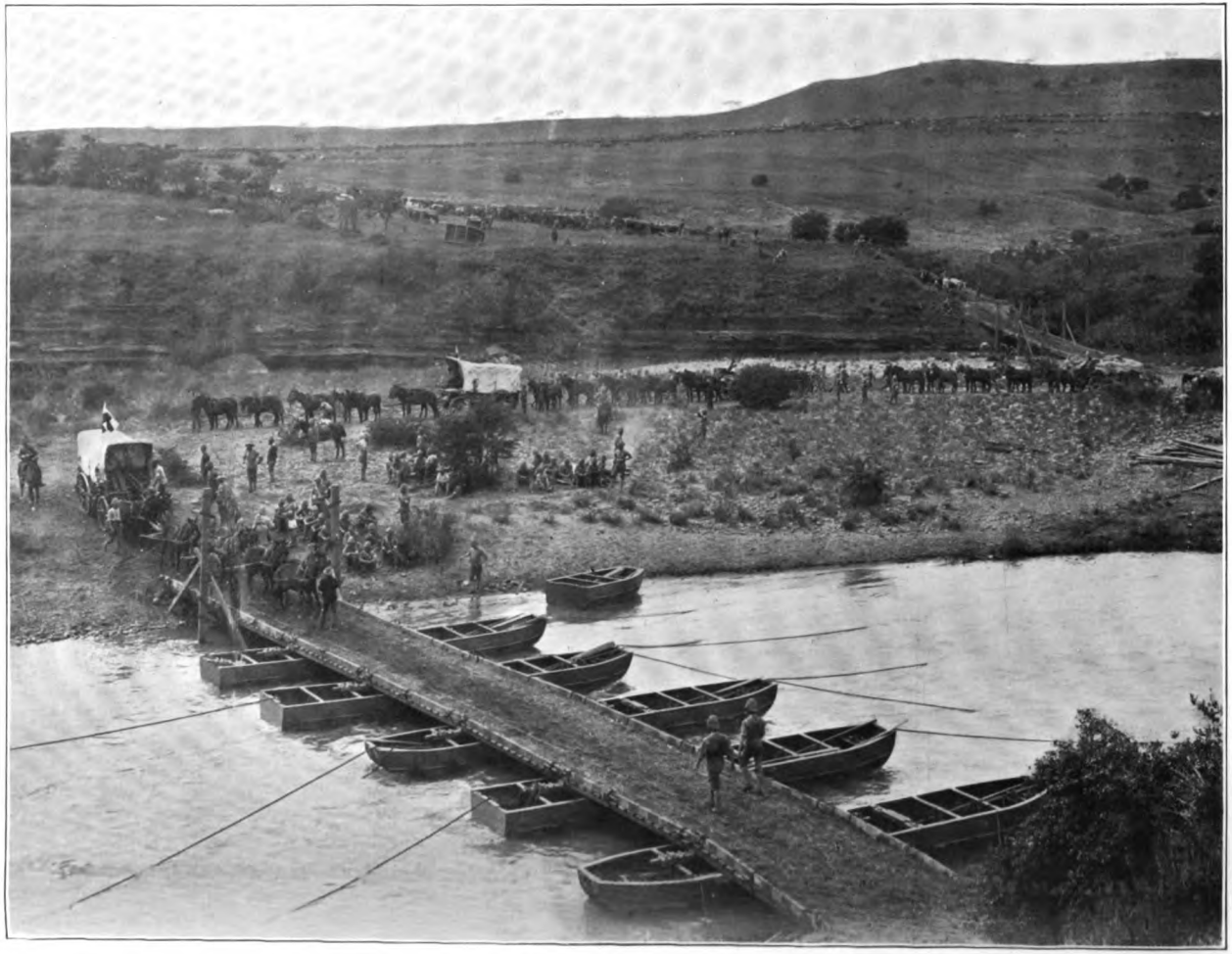

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THE PONTOON TROOP IN NATAL, 1899–1900.

I.—The first bridge constructed in Natal Campaign; over swollen spruit near Pretorius' Farm, on march from Frere to Springfield.

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THE ORGANISATION OF THE CORPS OF ROYAL ENGINEERS.

By 'NEMO.'

THE Army is passing through a period of re-organisation. The future of the Corps of Royal Engineers is now under consideration with the rest.

The subject is probably uppermost in the minds of most officers of the Corps, and it therefore seems appropriate to deal with it in our *Journal.*

The organisation of the Corps in Peace must be governed by the work it is required to perform in War and the organisation that will then be required for the execution of this work.

The work of the Corps in War may be broadly divided into :—

(1) General Engineering in the Field and in Fortresses.
(2) Telegraphs.
(3) Railways.
(4) Survey.

Each of these branches of work involves considerable organisation and special knowledge.

To carry out these duties four principal Officers are appointed to a Force in the Field :—

(1) A Chief Field Engineer, responsible to the Chief of the General Staff.
(2) A Director of Telegraphs, responsible to the Chief of the General Staff.
(3) A Director of Railways, responsible to the Quartermaster-General.
(4) A Director of Survey, responsible to the Chief of the General Staff.

The work for the execution of which these four Officers are responsible may be generally defined as follows :—

CHIEF FIELD ENGINEER.—Piers and landing places; roads; bridges; huts; cantonments; buildings of all kinds; water supply; engineering works in siege operations (attack or defence); construction and demolition of field defences; search lights; advance telephones; tramways; workshops for production of special engineer stores; ballooning.

DIRECTOR OF TELEGRAPHS.—Construction, extension, repair, maintenance, and working of all telegraph wires and offices, and of

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trunk telephone wires and exchanges; dealings with civil telegraph administrations and cable companies.

DIRECTOR OF RAILWAYS.—Construction, extension, repair, maintenance, and working of all railway lines; dealings with administrations of Civil Railways worked by Civil Staff and utilised by Army; control of movements of the Army on the railways; railway extension to siege or field works, whether in attack or defence.

DIRECTOR OF SURVEY.—Production of maps of the country as required by the Army; mapping of the greatest possible area for subsequent use.

To carry out the above work the three first-named heads of Branches require :—

(A). Regular Engineer Units formed of enlisted skilled artisans under Royal Engineer Officers;—to move about with the various forces, executing rapid construction and repairs and the work within the danger zone where disciplined troops are required, moving without delay from one place to another according to the emergency, marching and working under military conditions.

(B). An Engineering Staff and Personnel at the Base, on the Lines of Communication in the districts occupied by the Army, and at the front;—to maintain the work rapidly constructed by the Units of their branch; to administer and carry out all the Engineering Work in the districts; to raise and direct skilled and unskilled labour for the execution of the larger works which cannot be undertaken by constantly moving Units with limited numbers; to procure and organise the resources of Material and Stores which will provide both the Units and all the other Engineering personnel with the means of carrying on their work; to arrange Contracts, run Workshops, and account for Funds.

Thus, besides the regular Engineer Units, it is also necessary to have the administering Staff and subordinate personnel for "Engineer Districts" which remain more or less stationary;—to work and maintain the engineer works within them, while the Units pass from the control of one district to another according to the emergency, executing the rapid construction and repairs, carving out the work ahead.

An Engineer District may be at the Front, on the L. of C., or at the Base. In the case of the Field Engineers it would be in charge of a District Field Engineer, in the case of the Telegraphs in charge of an Assistant Director of Telegraphs, these controlling all the Units and Engineer personnel of their respective branches within it and being responsible to the General in Command of the Troops in that District

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or section of the Front or L. of C. The number of Field or Telegraph Units, or Engineering Staff and Personnel, allotted to any force would depend upon the amount of engineering work within the district in which that force was operating. The C.G.S., on the advice of the C.F.E. or D. of T. would distribute the Units and the administering Engineer Staff with its subordinate personnel among the various districts and forces; and he would alter the distribution from time to time, just as he alters the proportions of the various arms (Cavalry, Artillery, and Infantry) according to the nature of the military operations on which they may be engaged.

Thus, although a Field Company and a C.R.E. (or D.F.E.) might be allotted to a Division on mobilization, they would not remain with it unless there was sufficient engineering work to employ them in the portion of the country in which it was operating. The C.R.E. would be allotted to a District either at the front or elsewhere, and would remain in charge of that District whether one, two, three, or even no Divisions of the Army were operating therein. The Engineering Districts would, however, correspond, as a rule, with the commands of the Army, just as they do in peace.

On the Railways the district is also the unit; and a district staff, divided into the departments usual upon Railways and responsible to the Heads of those departments, would be provided for every Railway district constructed or captured. The Heads of the Railway Departments, with their supervising staff, workshops, and stores, would form the Central Railway Establishment under the General Manager; while the Railway Units, also under the General Manager, would carry out the new construction and the repairs. The General Manager is responsible to the D. of R. for the technical portions of that officer's duties.

Enough has been said to show that, besides the regular disciplined Units moving from one place to another, there is also required in each branch a large administering and maintaining staff of officers and subordinates, more or less stationary in the positions allotted to them. This organization requires to be directed by R.E. officers; but the subordinates may be partly formed of regular Units split up and partly of quasi civilians under Military Law, either raised at the time or previously enlisted in a special reserve.

Having thus roughly outlined the organisation in War, let us examine what our organisation should be in Peace. It should correspond exactly to the organisation for War. The nucleus of everything required in War should exist in Peace, with the machinery all ready for its expansion. It is not fair to ask any man to accept the post of Chief Field Engineer, Director of Railways, Director of Telegraphs, or Director of Survey and to create these large departments in forty-eight hours. These officials, with the nuclei of their departments, should in peace time be at the War Office, responsible

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to the member of the Headquarter Staff to whom they are responsible in war; thus the Chief Field Engineer and the Directors of Telegraphs and Survey would be under the Chief of the General Staff, the Director of Railways under the Quartermaster-General, in peace as in war. Their peace duties may be defined as follows :—

CHIEF FIELD ENGINEER.—Questions of establishments of Field Troops and of Field, Fortress, Balloon, and Bridging Companies: training of these Units for war duties; establishments of District Engineering personnel for war; technical manuals and administrative regulations; patterns and quantities of stores for Field Engineering; reserves of stores, and questions of reserves of personnel; estimates for and expenditure on training. All questions affecting Field Engineering.

DIRECTOR OF TELEGRAPHS.—Questions of establishments of Telegraph Companies, etc., etc., similar to duties of C.F.E. in his branch.

DIRECTOR OF RAILWAYS.—Similar duties to the above in Railway Branch; also all movements of troops by rail, agreements with Railway Companies, etc.

DIRECTOR OF SURVEY.—Similar duties to the above in Survey Branch; also production of all maps required by War Office.

We now come to the question of the surplus officers. It has been shown that a considerable number of officers and subordinate employés are required in war who do not belong to any Unit. Two questions therefore arise :—

(1). How are the surplus officers to be employed and trained in peace ?

(2). Whence shall we obtain in war the skilled subordinate employés required outside the regular Units ?

Taking (1) first, every encouragement should be given to officers to accept outside employment in the way that many now accept it. The training obtained in these outside appointments is excellent, and makes the officer more valuable when he returns to the Corps. For Railways or Telegraphs, it is absolutely essential that an officer should at some period be employed on a Commercial Railway or in the Post Office Telegraphs.

But these outside appointments are a precarious source of employment; the number offering must vary from time to time. It is therefore necessary that a branch of State work, which will give an all-round engineering training and a knowledge of engineering administration, should be handed over to the R.E. Officers required for war but surplus to peace establishment. It does not require much discussion to decide what this work should be. It stands to reason that Fortifications should be built by Royal Engineers; and as Barracks are in many places intimately connected with fortifications

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and give an excellent all-round training, these are the works for the surplus officers to carry out as a Department on civil lines.

The present arrangement of two departments existing side by side and both responsible for work in the same places, one military and one civil, fortifications, small barrack and other works, lands, etc., under the former and new Barrack Construction under the latter, each with its own staff and stores, would appear to be uneconomical and wasteful of public money. The Barrack Construction Department should afford employment for the surplus R.E. Officers.

But, contrary to the custom of the past, the surplus officer Department must not in any way control or deal with the work of the other branches of the Corps, viz.: Field Engineering, Railways, Telegraphs, Surveys. In the past the Head of the Barrack and Fortification work was Head of the other branches of the Corps work and directed the war training, with the result that the mass of work involved in the peace Department overshadowed the more important but less apparent necessity of war training; officers and men were in many cases entirely cut off from war training and employed on the peace works. The officers who were so busy on these peace works had little time to study the proper organisation and development for Field Engineering, Railways, Telegraphs, and Survey, and to direct the proper policy for studying and working on these branches.

The Head of the peace Department of surplus officers should be under a member of the Headquarter Staff who does not exist in war, *e.g.* the Master-General of Ordnance, and should only obtain the services of officers or Units in other branches with the consent of their Heads. Thus there will be no possibility of the surplus officer peace Department again absorbing all the war branches.

So much for the organisation at Headquarters. In the districts it would be similar. On the Staff of every G.O.C.-in-Chief in a Command would be :—

(1). A "Chief Field Engineer," commanding all Field Engineering and Fortress Units, supervising their training, carrying out for the General all engineering works in connection with the manœuvres and training of his troops, responsible to the Colonel of the General Staff.

(2). An "Engineer for Works," commanding all surplus R.E. Officers, and carrying out for the G.O.C. all peace works, *i.e.*, barracks, permanent fortifications, lands, etc., responsible to the Brigadier i/c Administration.

(3). Where telegraph companies exist an "O.C. Telegraph Companies" to act as Director of Telegraphs to the G.O.C.

(4). Where Railway Companies exist an "O.C. Railway Companies."

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Now as to the vexed question of specialisation. It is not required, at least only to a limited extent. It is not necessary to divide the Corps into the five hard-and-fast branches denoted above, nor would it be advantageous to do so. We must be "*Jacks of all trades and masters of one.*" If we were divided up the establishment of the Corps would be much increased.

All Branches must draw their personnel from a common pool controlled by the representative of the Corps in the Adjutant-General's department, and the pay of all must be the same. But this important proviso should be made, that at the War Office, where the policy of each Branch is worked out and controlled, the Head of every Branch and also his Staff must be men who have spent 50 per cent. of their service in that branch; *e.g.* an officer who has spent half of his time in Fortifications and Works and a quarter as a Field Engineer should not be appointed D. of T. To the Head Office should be appointed experts to control and guide those outside in the way they should go, but specialisation should not be carried any lower down the scale. The result of the proposed system would be that nearly every officer would alternate between one particular Branch and the F. and W. Branch, in the latter becoming jack of all trades, in the former master of one.

As regards pay and conditions of service, no alterations are necessary; let us leave well alone. We get the right class of officer and we enlist excellent men, because the pay has been fixed at the minimum rate which will attract them. In spite of our extraordinary organisation in the past we have acquitted ourselves fairly well. If we could get a really good organisation we should in the future do fifty times better.

It remains to answer question (*2*)—Where shall we obtain in war the skilled subordinate officers and employés required outside the regular Units?

The Telegraph and Railway branches must induce civilian employés on telegraphs and railways to join a special Reserve to come out in War. This class is comparatively limited and careful arrangements must be made in peace to secure a sufficient supply. With the Field Engineer personnel however the case is different. The general practitioner engineer or artisan is a drug in the market and can be secured at market rates at very short notice.

This concludes a rough outline of an organisation for the Corps. The *main point* is to maintain in peace at the War Office a Chief Field Engineer, a Director of Telegraphs, a Director of Railways, a Director of Surveys, and a Director of Fortifications and Works; and to let each Head work out the salvation of his own Branch, under the member of the Headquarter Staff to whom he is responsible in war.

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THE ORGANISATION OF ROYAL ENGINEERS FOR THEIR DUTIES IN WAR.

By Bt. Colonel G. K. Scott-Moncrieff, c.i.e., R.E.

A few years ago, when in China and associated there with the engineers of several other armies, I was asked by one of our German colleagues if we would explain to him the organisation of the Corps of R.E. Two of us therefore sat down with him, the *Supplement to the R.E. Journal** before us, and endeavoured to explain the intricacies of the Bridging and Telegraph Battalions, Submarine Miners, Field and Fortress Companies, and so on. He asked us many questions, and as we endeavoured to explain, his face assumed a more and more puzzled expression ; and though he was too polite to say so, he evidently thought that however excellent our material the organisation was utterly chaotic.

To us, who were endeavouring to explain matters, it appeared that there was little to be said in defence of our organisation, and that in this, as well as in many other respects, we, in the British army, were "muddling along somehow." A comparison of our organisation of military engineers with that of even a third-rate European power is sufficient to show anyone that we have a very great deal to do before a satisfactory state of affairs is arrived at.

It is, however, easy to act the captious critic. It is far more difficult to suggest remedies which shall be in accordance with the requirements of the army in war and yet be within the limits of administrative possibilities in time of peace.

A War Office Committee under the distinguished presidency of Field Marshal Sir Evelyn Wood has recently been sitting to consider this matter. What the conclusions of this Committee are I do not know. But as the R.E. Institute has invited papers on this very question, I venture to join the number of those who have already contributed articles.

Necessity of Considering the Matter from the Peculiar Standpoint of the British Army.

Although I have alluded above to the organisation in foreign armies, I must qualify my remarks by saying that it is not sufficient in all things to follow their lead. Our military reformers have a tendency to follow, in matters chiefly of military millinery, the lead of the nation that has been most victorious in a recent campaign. After the Crimea and Italian Campaigns everything in the British army was

* Now the *R.E. Monthly List.*

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modelled on a French basis, even the British soldier's shako being an imitation of the French *kepi*. But when France was beaten by Germany in 1870 German methods, tactics, helmets, etc., were first and the rest nowhere. Nowadays we are bidden to turn our eyes to the Far East, and *Punch's* recent skit on the British policeman dressed in Japanese fashion has a certain significance behind the jest.

Fortunately all this has not much affected the Sapper, except possibly in the bewildering variety of headgear (I have had fifteen different patterns during my service); officers and men are much the same stuff as they used to be.

In considering the case as it is affected by the peculiarities of the British army, I begin by a few axioms.

1. The British army being a voluntarily enlisted body of men, the majority of the men in the infantry come from the labouring class, and they are neither so intelligent nor so well educated as are the average conscripts of foreign nations. Although the British soldier is, by virtue of his voluntary service, probably a better fighting man than one who is forced to serve, yet in every company of foreigners there is probably a higher proportion of intelligent educated men than in a British company. Hence there is the greater need in our service for a goodly proportion of engineer soldiers recruited from the intelligent artisan class.

2. The British soldier has frequently to fight with savage or semi-civilised foes in superior numbers. The paucity in our numbers must be compensated for by skill in weapons, fortification, and other devices of the brain.

3. The British Empire being scattered all over the globe, the garrisons at distant spots must be based on the possibilities of operations in adjoining countries. Therefore such garrisons must have a due, though not an excessive, proportion of engineers.

The broad deduction from these axioms is that, whatever may be the proportion of engineers to other arms in the armies of civilised nations, it is essential that in the British army that proportion must be comparatively high. Taking as a unit the infantry division, it appears that in most European armies the proportion varies between 2 and 3 per cent. In the Swiss army it is 4·21; in the Japanese 4·10 per cent.; in the Russian army in Manchuria last year it seems to have been 5 per cent. In the British army, if we include the drivers of a Field Company, the proportion is 2·62; but if we consider only the dismounted men (who are really the skilled engineers) the proportion is no more than 1·87 per cent.

Hence we see that, although the engineers in a British division ought to be at least as numerous as in the Russian and Japanese armies, and indeed, if the above axioms are worth anything, the British sappers ought to be in a relatively higher proportion—yet as a matter of fact they are only 1·87 instead of at least 5 per cent.

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DUTIES IN THE FIELD.

The above argument is still further strengthened when we consider that in the British army there are certain duties necessarily devolving upon the R.E. which in other armies are carried out by other corps. Allusion has been made by Capt. J. E. E. Craster, R.E., in one of his recent papers in the *R.E. Journal* on this subject, to the "water-tight compartment" in the German army and its practical disadvantages. As pointed out by him, the British engineers are trained for general duties. They may be individually specialists and should be employed accordingly when necessary; but they are available, with some trifling exceptions, for general duty, and it is their pride that they are "handy men." Especially in savage countries they are called upon to do work beyond the scope of military engineering pure and simple. Roads, waterworks, and military buildings, for whose construction and maintenance no provision is contemplated in foreign armies, are regularly and definitely accepted in the British army as among the duties in the field of the R.E. In some of our campaigns (*e.g.*, Afghanistan, 1878–80) these formed the bulk of the work done by the engineers. If we have another campaign in Afghanistan it is certain that similar works will furnish a large field for employment. In most foreign armies these works would be carried out by civil engineers or architects. The possibility of having to undertake such works in war therefore furnishes a very strong argument for the employment of the R.E. on civil or quasi-civil works in peace.

In addition to all duties on lines of communication, camps, fortified forts, and bases of operations, there are others of a tactical nature in which the engineers of an army have a distinct *rôle*. The late Colonel R. Home, R.E., in his *Précis of Modern Tactics*, pointed out these latter duties some 30 years ago; but it is only recently, chiefly owing to the skill with which the Japanese used their engineers in attack, that these principles have come into prominence. The rapid application of fortification to pivot points in the battlefield, the hasty improvement of positions gained, the demolition or removal of obstacles, are all matters in which the engineer soldier must be trained to co-operate with other arms. To carry out these duties properly it is absolutely necessary that with every body of infantry and cavalry there should be a due proportion of engineers, whose tools and other implements necessary for their work should be carried in the way best adapted to the locality and in a manner which will enable them to be always available when needed. The conclusion arrived at is that with each brigade of infantry there should be a field company and with each cavalry brigade a field troop of R.E.

I may perhaps add that in the operations of the 3rd Cavalry Brigade and the 7th Infantry Division in Ireland this year the tactical

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use of the R.E. was fully recognised with much advantage generally. It was, however, a new tactical feature to many officers who were engaged in these operations.

Besides the duties above indicated there is another, alluded to by Colonel Kenyon in the August number of the *R.E. Journal*, viz. :— the telephone service. From the experience of the Irish manœuvres this year it is evident that infantry, cavalry, and artillery are quite capable of working their own telephone service with the simple and effective apparatus obtained this year, supplemented by various improvised methods of carrying the wire. But skilled electricians, instrument repairers, etc., are required in the R.E. companies, and it is most essential that some part of each R.E. field troop and company should be devoted to this service. I do not however agree with my old friend Colonel Kenyon that the title of the R.E. field units should be changed. To call all these units "telegraph companies" might give rise to the idea that they were specialists in one branch only and not the all-round useful men they ought to be. Let the existing telegraph companies concentrate their energies on the work they have hitherto carried out on lines of communication and in camps; but the field troops and companies should supply the skilled expert assistance to the other arms, who are well able to work their own telephones in the field.

Field troops and companies must also carry apparatus for the water supply of camps, etc.

ORGANISATION OF EQUIPMENT IN FIELD UNITS.

From the above considerations we see that the equipment of field units should include

1. Tools for all probable military operations.
2. Explosives for anticipated demolitions.
3. Telephone apparatus, with means of repairing and testing.
4. Water supply gear.

The equipment should further be so subdivided that each section of the troop or company may be complete in itself, and thus able to proceed independently with the corresponding unit of the cavalry or infantry brigade to which it is attached. There may be in addition a small headquarter reserve of equipment.

The distribution of trades of the sappers and the best methods of equipping them are subjects hardly within the scope of this paper; but something may be said about the transport of field units. At home this mainly consists of vehicles of a special pattern, which permit of a limited number of sappers riding on them. Pack animals are allowed to a very limited extent.

In the Indian Sapper and Miner companies the whole of the transport is on pack animals, subdivided in 3 lines, into the details of

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which it is unnecessary to enter. This organisation is good in so far as it recognises the essential need of pack transport with a sapper troop or company. But it is imperfect in so far as it does not provide for a more rapid rate of progress than that which can be produced by the marching of men.

It is most desirable that the equipment should, in civilised countries, be a combination of wheeled vehicles and pack animals. The former should be able to take a limited number of sappers at a trot over ordinary roads in order to strengthen pivot points, destroy a bridge, etc.; while the latter are necessary to accompany sappers over ground where carts cannot follow.

The transport of a company and its drivers are a variable addition to the integral parts of the company, which are the skilled workmen and the tools. European drivers, horses, wagons, etc., may, under certain conditions, be entirely dispensed with, the war efficiency of the unit being still maintained. It is possible that in the future a solution of the transport question may be found in automobiles, combined with pack animals of some sort, which are almost indispensable. In any case cyclists are most useful. When I commanded a field company I had a bicycle club among the men, and gave certain privileges to the members provided they allowed their machines to be used on the march, etc. I think this added materially to the war efficiency of the unit, for it provided a means of rapid movement for the sappers. I consider that this is an important point in connection with field troops, for much of the work that is allotted to mounted sappers, in civilised countries at least, could be done by cyclists, with a corresponding reduction in horseflesh.

Before dismissing the question of the organisation required to link the sapper and his tools, I must refer to another important point. Each field company is now equipped with 2 pontoons and superstructure. This of course involves two teams of horses with their drivers. It would, I think, be better to have in lieu a separate bridging company, with about 50 yards of bridge material, attached to each infantry division. This is the organisation in the German and Japanese armies.

If the field company or companies of a division have to make the bridges for an advancing column they cannot take their place with other troops as tactical units. An example of this occurred in the Irish manœuvres of 1904. A bridge train had been extemporised in one of the field companies, and an important river, about 100 yards wide, was bridged at the beginning of a long day's operations. The force that crossed the bridge had to work over a difficult country where they needed their sappers badly; but the sappers were tied to their bridge, not only until all the force had passed but subsequently until the bridge was dismantled, and their services as a tactical unit were lost for the time.

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It is of course admitted that bridging companies should be taught other fieldworks, and that the "general service" company should be thoroughly instructed in bridging. But the ideal organisation of sappers with an infantry division is a company for general service with each brigade and a bridging company for the division generally.

Whether our bridging companies are organised in the best manner in respect of equipment and horses is doubtful. Our pontoon wagons require six-horse teams, yet the Japanese have a pontoon drawn by one horse. A Japanese pony, a miserable creature compared with an English draught horse, certainly cannot drag the same load as the latter. Either therefore the Japanese have hit upon some very much lighter pontoon than ours, or our pontoons have too many horses. It is true we overload our draught horses with heavy and unnecessary harness, but I think also we do not use the proper stamp of animal. We do not want the same class that is required in horse or field artillery. A heavier and more powerful animal is needed, more of the Clydesdale or Shire stamp; two of these would walk away with a pontoon wagon. There is also no necessity for postillion driving.

It is admitted that a half-bred Clydesdale costs much more than the average army draught horse, but the initial cost would be compensated by fewer numbers. It would probably not be worth while to keep up, in our Remount Depôts, a supply of such draught horses for R.E. purposes only. But what about the Army Service Corps? A heavier class of draught horse would be most valuable and economical to them.

So far then I have suggested that the engineer requirements of an infantry division are two field companies and one bridging company. There remain a few small miscellaneous detachments.

Every general of division should have a field printing press to enable him to issue copies of orders, and a field lithograph press to enable him to circulate copies of plans and sketches. These are most important adjuncts. For discipline and interior economy the small *personnel* concerned might be attached to the bridging company; but their services should be utilised under the direct control of the C.R.E. or the Colonel on the General Staff.

A small detachment with a search light plant, preferably two such plants, might well be added. The total number of the various miscellaneous detachments need not be more than 30 men and they might all be attached to the bridging company.

The whole of the three companies on war strength, exclusive of drivers whose numbers would vary with the country, would consist of 18 officers and 450 rank and file. There would also be a lieut.-colonel as C.R.E. and an adjutant with sergeant-major and clerk. The proportion of sappers to a division 9,000 strong would thus be 5 per cent. This allows of 150 sappers to each field company, 120

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sappers to the bridging company, and 30 to miscellaneous detachments. Including drivers the strength would be about 600. The whole should constitute a "Field Brigade of R.E."

Search light companies, telegraph companies, balloon sections, and field parks belong to the organisation for lines of communications.

FORTRESS COMPANIES.

Having never served in a fortress company I feel some diffidence in approaching the question of its organisation. I do not, however, go so far as Colonel Kenyon in his advocacy of their abolition or amalgamation with fortress artillery.

A fortress company differs from a field company in that the former do not hold in peace the tools required for war and do not possess transport and drivers (the latter always a variable item as previously pointed out). In all other essentials the companies are identical. There is not, for instance, the distinction between them that there is between field and garrison artillery. Thus it is possible to transform a fortress company into a field company at once by issuing to it the necessary equipment, transport, and drivers.

The duties of engineers in fortresses would appear to be :— (1) Electrical work in search lights and communications, (2) Construction and repair of defensive works.

There are, however, certain fortresses where it is not desirable to keep field companies, but where the fortress companies must be prepared to take the field with other arms in event of expeditionary forces being required in adjacent countries. This applies to such places as Hong Kong, Malta, and perhaps some others.

Otherwise there seems to be no reason why the strength of the fortress companies should exceed 5 per cent., at most, of the rest of the garrison.

This would give about 9 fortress companies at home, and a similar number abroad. I would suggest that these 18 should be organised in 6 Fortress Engineer Brigades, each of 3 companies, viz. :—

(1). *Channel Brigade*, headquarters Portsmouth ; Companies or detachments at all English Channel fortresses from Dover to Falmouth.

(2). *North-Eastern Brigade*, headquarters Chatham ; Companies or detachments at all North Sea ports or fortresses from the Firth of Forth to the Thames.

(3). *Irish or Western Brigade*, headquarters Belfast ; Companies or detachments at all the Irish Channel ports or fortresses from Greenock to Cork.

(4). *Mediterranean Brigade*, headquarters Malta ; Companies at Gibraltar and Malta.

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(5). *East Indian Brigade*, headquarters Singapore; Companies or detachments in China, Singapore, Ceylon, and Mauritius.

(6). *West Indian Brigade*, headquarters Bermuda; Companies or detachments at Bermuda, Barbados, Jamaica, and possibly Capetown.

As Esquimalt and Halifax are being taken over by Canada, these stations are not included. Egypt ought surely now to be able to have native sappers, as in India.

OBJECT OF BRIGADE ORGANISATION.

The term "brigade" for field and fortress groups is used in default of a better term to express an organisation similar to a brigade of other arms, especially of horse or field artillery.

The grouping of field batteries has only come into vogue of recent years and is an acknowledged advantage. The duties and responsibilities of battery commanders have not been impaired or altered, but the brigade system admits of better training and supervision. In India it has not been carried out (at least it had not been when I left 18 months ago) and the defects, which there exist, of single battery organisation have frequently been pointed out to me by senior artillery officers. Exactly the same defects exist in our company organisation. It is not so bad now as it was some few years ago (I remember, for example, two companies in the same station with different drills, different patterns of saddlery, different vehicles, etc.); but still there is a want of cohesion. One C.R.E. may take an interest in military details and frequently supervise the companies at drill, field works, riding, etc.; another may leave these details severely alone, as though they were no part of his duty.

Now, however capable the company commander may be, his company will never take its place in line with other arms unless the C.R.E. sees that it is properly worked. The influence that a C.R.E. has with the general and his staff will necessarily be much greater than that of a junior officer. The C.R.E. should be the responsible authority on the tactical use of the Engineers in a division, just as the brigade commander of the artillery is with respect to that arm. The C.R.E. should not only see that the prescribed annual courses of the companies are carried out, but that they are carried out in accordance with definite tactical schemes, that they touch the training of other arms, and that they suit the conditions of the locality. Company officers cannot do this. How often we see sapper companies sent off into a corner by themselves, carrying out work which may benefit them but does no good to anybody else; this is most pernicious.

As regards drills it is perhaps unnecessary to say that the proposed grouping of units is not intended to relieve company officers of the

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responsibility for drills and exercises which now devolves upon them. With infantry the company is now recognised as the tactical unit, and this is the case even more definitely with engineers. Battalion drill is very necessary and useful in training recruits; but it is so seldom required by engineers in war that it need not be practised by their service companies in peace. Drills should be carried out by company officers and limited to what is really needed. There is plenty of varied instruction to be obtained in the limited time available; and I have never yet seen a company in which there was not room for improvement in company drills, riding, driving, signalling, judging distance, bayonet fighting, and physical training. In all these matters the C.R.E. ought only to exercise general supervision.

It would be a very great advantage, too, if promotions and transfers could be arranged either in brigades or among companies of the same class, instead of in the Corps at large. At present it is most disheartening for company commanders to have constant changes. A more decentralised system of promotion would be much more satisfactory.

The headquarters of each field engineer brigade would be the headquarters of the division of the army to which it is attached, and the sub-district C.R.E. would be its commander. The companies need not necessarily be all at one spot; they could be quartered in the district with the infantry brigades to which they are attached.

GENERAL QUESTION OF STRENGTH IN PEACE.

Taking all the field and bridging companies at a peace strength (exclusive of drivers) of 100 each, field troops at 30, and fortress companies (including electricians for coast defence) at 100, we have, according to the above proposals, for 4 cavalry bridges and 9 infantry divisions:—

4 field troops at 30	= 120
27 field and bridging companies at 100	=2,700
18 fortress companies at 100	=1,800
Total	=4,620

The present strength of dismounted men in field troops and companies, fortress companies, and coast defence electricians is 5,041. Thus there would be a balance of about 400 men in favour of the proposed organisation. Against this, however, there would be an increase of some 200 drivers and a considerable increase in horses. But the substitution of a heavier class of horse (as suggested above) would bring down the number both of horses and drivers; so that generally I think the proposals would result in public economy.

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EMPLOYMENT IN PEACE.

The best utilisation of Sapper skilled labour in time of peace is a most difficult question, and space does not permit of its discussion here. It would be in every respect desirable that any engineering works carried out by the State should, in part at least, be entrusted to the R.E.; but unfortunately any such arrangement is subject to the necessary interruption caused by military training.

Field troops and companies can also be most advantageously employed in peace as instructors in field works and surveying to the cavalry and infantry brigades to which they are attached.

CONCLUSION.

The suggestions made above affect only the bulk of the units of the Corps, viz., those in the bridging, field, and fortress companies.

A proposal which increases the bridging at the expense of the fortress companies will possibly meet with adverse criticism. But those who object will, I think, recognise that the proposals correspond with the recent organisation scheme for the whole army, viz., the maintenance of eight infantry divisions at home and one in S. Africa, plus certain troops for coast defences and colonial garrisons. As regards the reduction of fortress companies I do not deny that, as they exist, they are usefully employed in peace; but I submit that in respect of war organisation they are in excess, while the field units (including bridging companies) are too few.

I have not touched upon survey companies, railway and telegraph companies, field parks and depôts; as far as I know, these seem to be suitable. Nor have I said anything about militia or volunteers, as the length of this paper has far exceeded the limits of my original intentions. I need only say that although engineer militia and volunteers are organised in battalions, they should be allotted to brigades and divisions of the home defence army in exactly the same way as advocated above for the field and fortress companies of the regular forces.

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CAMP OF INSTRUCTION AND MANŒUVRES OF THE 3rd CAVALRY BRIGADE IN IRELAND, 1905.

By Bt. Lieut. Colonel H. R. Gale, R.E.

CAMP OF INSTRUCTION.

The Training of the 3rd Cavalry Brigade during its Camp of Instruction at Lusk, near Dublin, brought into prominence the possibilities of the Royal Engineers becoming an Instructing Body for the rest of the Army.

Owing to the great increase of late years in the technical training of all branches of the Army, the Royal Engineers are not alone in possessing knowledge of subjects which require some scientific education, such as Surveying, Fortification, and Bridging. It seems necessary, therefore, that we should consider the question of our future position in the Army, and make sure that our expert knowledge and our capabilities are fully utilized in the future; otherwise some people in other branches of the Army may come to the conclusion that they can do without Field Engineers and that some battalions of Pioneers will suffice for all their needs.

For these reasons, even more than for the actual engineering interest of the work done, a short description of the Camp of Exercise at Lusk may be of interest to the Corps.

The Camp commenced on Saturday, 8th July, on which day 4 Cavalry regiments and 1 Brigade of Royal Horse Artillery marched in from Dublin and the Curragh. One regiment, the 11th Hussars, made the whole march of 44 miles from the Curragh in one day. The 5th (Field) Company, R.E., under Major F. E. G. Skey, had already been a week in camp, preparing stores and carrying out part of their own Field Works' training. Sunday was devoted to rest and shaking down into camp life; and the fire mains of the Remount Establishment had also to be connected up to the water supply to supplement the 1-inch and 1½-inch pipes to the various camps, which were found insufficient in size.

By 8.30 on Monday morning, the Naval portion of the concentration was also complete. This consisted of:—The Transport *Kansas*, 5,000 tons, an old Atlantic cattle-steamer, hired for the work; 6 horse-boats and flats, to hold 7 or 10 horses each; and H.M.S. *Donegal*, 1st class armoured cruiser, which arrived from Portland and dropped anchor inside Lambay Island in the small hours of the

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morning. The first work of the *Donegal* was to take the Government Steamer *Evelyn Wood*, containing the horse-boats, alongside and hoist the boats out of her, the *Evelyn Wood* having no derrick strong enough to take their weight. By 8.30 a.m. the horse-boats had been towed the mile and a half between the ships and the shore by 3 steamboats which the *Donegal* had brought.

The instruction which then commenced was divided into four sections :—

1. Embarkation.
2. Bridging.
3. (*a*). Swimming (men and horses).
   (*b*). Rowing.
   (*c*). Field Entrenchments and Demolitions.
4. Detached Duties ;—Reconnaissance, Outposts, etc.

A separate Unit was detailed for each Section, and changed every day. The 12 working days of the Course, after deducting one or two for schemes of combined operations, allowed of each unit having two or more days' practice in each section. Work usually began at 6 a.m., which meant reveillé at 4.30 a.m. so as to allow time for looking after horses, breakfasting, and marching the 2½ miles between the camp and the beach.

The Camp was on the Government Remount Farm, close to the village of Lusk, 12 miles north of Dublin. The portion of the coast used for the Instruction consisted of 4 miles of sandhills, bounded on the north by the low rocky promontory of Rush and on the south by a similar headland at Portrane, the whole being sheltered from the east by the Island of Lambay. In the middle was Rogerstown Inlet, the tidal estuary of a small stream, with a narrow entrance in which the tide-run was very strong. This entrance, about ½ mile long, answered well for Bridging, Swimming, and Rowing, giving excellent practice in strong currents, and, at the hours of slack tide, in still water also.

1. EMBARKATION.

In the Embarkation Section, the *Donegal* at first did most of the work. Her crew supplied working parties on the shore and on the *Kansas ;* worked the winches on the latter and the 3 steamboats which towed the horse-boats to and fro ; put crews into the horse-boats ; and, in fact, carried out all arrangements between the Transport and the Beach. The Military working parties in the Transport and on shore at first confined themselves to the handling of the horses and to pulling on the shore-lines when required, as contemplated in the "Regulations for Embarkations" and carried out at Clacton in 1904. But as the practice proceeded, the Naval working parties were considerably reduced ; and, at the end, it was

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found that the troops were quite able to supply all the labour, with the following exceptions :—

(i.). A small party on the Transport to work the winches,
(ii.). The crews of the steamboats,
(iii.). One seaman to each horse-boat and lifeboat,
(iv.). A small Naval Party on shore to superintend the anchors, buoys, lines, and other hauling-in arrangements.

In real operations this would have set free all but a small part of the *Donegal's* complement for the much more important duties of guarding against attack from the sea, beating down opposition to a disembarkation, or retarding pursuit in case of a re-embarkation.

The Embarkation work and most of the Disembarkation was carried out at the flat sandy beach near Rush ; but part of the disembarkation was done in Rogerstown Inlet, where the steeper slope of the sand allowed of bringing the boats nearer the water's edge. Work was carried on irrespective of the tides, but Rogerstown Inlet could only be used near high water on account of the shallowness of the bar. The day's work generally resulted in somewhere about 100 horses being shipped and landed again, with the addition, on some days, of guns, pom-poms, wagons, etc. Every day, also, from 15 to 30 tons of forage were landed from the *Kansas*, which had brought a supply from Liverpool where it could be obtained better and cheaper than locally.

The hours of work were from 6 a.m. to 4 or 5 p.m., and on one day to as late as 9 p.m. The reasons which prevented more being done in the time were chiefly as follows :—

(1). There were only two gangways and derricks on the *Kansas*, available for the hoisting of horses.
(2). The anchorage of the *Kansas* was a mile and a half from the shore.
(3). One or more of the 3 steamboats had frequently to be used for other work, or was under temporary repair of small damages.
(4). The extremely flat foreshore made it very difficult to keep the horse-boats afloat, especially when embarking on a falling tide.
(5). The distance between high and low watermarks was nearly 500 yards. The steamboats, towing horse-boats, had to drop the latter in water from 4 to 6 feet deep, often 300 or 400 yards from the water's edge ; the horse-boats had then to be hauled in to where they could be filled or emptied, in water 2 to 3 feet deep ; this was slow and heavy work, on account of the great length of lines lying on the sand and cutting into it.
(6). The want of small steam or petrol boats, suitable for work between the ships and the shore.

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The actual loading and unloading of the horse-boats, and slinging horses into and out of the *Kansas*, took up a very small proportion of the whole time. At the beginning of the practice a pair of horse-boats took from 5 to 15 minutes to load; at the end, this time had improved to under 2 minutes. This improvement was in spite of the fact that, at the end, the men were in marching order and rode their saddled horses on to and off the boats; while, at the commencement, the men were in the lightest of clothing and led their horses with no saddles on them. The emptying and filling of a pair of horse-boats alongside the Transport could be done, at the end, in the very short time of 4 minutes.

Over 1,000 horses were embarked and disembarked during the whole practice.

2. BRIDGING.

The Bridging Section was superintended by an R.E. Officer as Instructor, with Assistants from the 5th (Field) Company, R.E. The following were regularly practised:—

1. Barrel-piers and rafts, with several different sizes of barrels.
2. Flying-bridges, of pontoon or barrel rafts, running on wire cables.
3. Boat-piers.
4. Trestles.
5. A foot-bridge of ladders and planks supported on single barrels, steadied by means of spars lashed across it at each barrel. These spars quite prevented the awkward rolling to which such narrow bridges are subject.
6. A raft to carry a gun, made of a waterproof water-tank stuffed with hay and with the edges gathered and lashed on the top.
7. A raft to carry one man, made of camp-kettles, in two rows of 7 each. Each row was lashed to light battens, and other battens were lashed across to connect the rows and give the man a seat. The tops of the kettles were fitted on with grease so as to make them watertight.

The 5th Company made a jetty of trestles and planks, and also a broad gangway of plank bowstring-girders, both of which were very useful for landing the forage from the *Kansas*. The hay-stuffed mattress was quite capable of taking a Horse Artillery gun and two or three men across the Inlet, the wheels being taken off and laid over the gun on each side. The solitary paddler of the "Dixie" raft became quite a feature of the waterside.

3. SWIMMING AND ROWING.

The Swimming and Rowing for men were superintended by a Lieutenant and Assistant Instructors from the *Donegal*; the Swimming for horses by the Riding-master of one of the Cavalry regiments.

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Many men were taught to swim; and towards the end of the practice the standard of rowing had become quite good, though not quite sufficiently so to warrant a challenge to the *Donegal*.

The continual practice of all the horses at Swimming was so effectual that, during the Camp, 1,000 out of the total of about 1,500 were swum across the Inlet away from home, with a man guiding each; the distance was 70 to 80 yards. A good deal of swimming was also done by the horses during the embarkation work, when they were often allowed to jump out of the horse-boats in comparatively deep water, half a mile or so from shore. Some horses even swam a considerable distance with saddles or harness on, though this was considered too hard a test to be habitually practised. The only horse drowned during the operations was one which was jammed by the tide under a small private jetty in Rogerstown Inlet, while at swimming practice.

ENTRENCHING AND DEMOLITIONS.

The Sub-Section for Field Entrenchments and Demolitions was superintended by an R.E. Officer, with Assistants from the 5th (Field) Company, R.E. Instruction was given in the simpler forms of field-works and gun-cover likely to be useful to Cavalry and Horse Artillery; and also in Demolitions such as could be carried out by Cavalry Pioneers.

The ground available being very sandy and loose, it was difficult to construct satisfactory works without revetments, for which there was not much material available. Much instruction was, however, given in the best shapes of trench and in the methods of handling many different kinds of explosives.

4. DETACHED DUTIES.

The wide stretch of open sand at low water gave opportunities for drill under Section 4; but otherwise the country was not very well adapted to detached duties, being somewhat hemmed in by the sea and the various estuaries and being also cut up into very small enclosures.

LECTURES.

Lectures on various subjects were a great feature of the Instruction. Some were to all ranks, in the open; others to Officers and N.C.O.'s only. For the former, a deep hollow amongst the sandhills formed a fine theatre, the lecturer's voice being heard almost as well in the "Gallery" as in the "Stalls."

The subjects treated were:—

(1). The work of the British Army, with special bearing on Landings;—3 lectures by T. Miller Maguire, LL.D.

(2). Embarkations;—by Lieut.-Colonel Telfer-Smollett, author of the Prize Essay of the R.U.S. Institution for 1904.

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(3). Penetration of Modern Firearms ;—by Colonel L. C. Jackson, R.E., C.R.E.

A method of quickly lighting up obstacles in front of a position by means of bonfires—with practical demonstrations ;—by Colonel L. C. Jackson.

(4). Wireless Telegraphy ;—explanation of the installation which was in regular operation between the Camp and H.M.S. *Donegal ;* also description of the lecturer's trip inland with a light cart carrying the necessary instruments, when he succeeded in getting communication with the *Donegal* from a distance of 10 miles ;—by Lieut. Rigg, R.N.

In addition to the C.R.E., other R.E. Officers were employed as Staff Officers or Instructors in the Embarkation, Bridging, and Field Entrenchments Sections. The 5th (Field) Company, R.E., also supplied numerous Assistant Instructors, as well as carrying out the more technical work in connection with the Bridging Section.

It will thus be seen that the Instruction given at the Camp was practically divided between the Navy and the R.E. In these days of scientific training for all branches, there seems to be a great, if hitherto somewhat neglected, field for the Corps of Royal Engineers as advisers and instructors. It is true that we are no longer alone in possessing knowledge of engineering matters. But the correct inference to be drawn is not that we are no longer necessary and can therefore be abolished or reduced to the position of Pioneers ; it is rather that, with the fullest measure of scientific education and training for ourselves, we should cultivate and be given every opportunity, by constant and regular work in conjunction with the other arms, to cultivate a teaching faculty which will enable us to pass on our knowledge to the rest of the Army.

THE SHANNON MANŒUVRES.

The Shannon Manœuvres, from the 8th to the 19th August, gave the 3rd Cavalry Brigade opportunities of using, in a practical way, the knowledge of swimming, boating, and bridge-making which they had acquired at the Camp of Instruction at Lusk.

The great natural frontier formed by the river Shannon and its lakes between the Provinces of Leinster and Connaught was utilized for the purposes of the Scheme, which was a most realistic one.

The 4 Cavalry regiments and the Brigade of Horse Artillery were divided into two equal forces, which acted as the small regular mounted forces of two States, Leinster and Connaught, which, at the commencement of operations, were on the verge of war. Ulster and Munster were at first neutral ; but later on the latter joined

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Connaught with a small force of Mounted Infantry, and made a great difference to the progress of the Scheme.

The first few days were spent in watching the 50 miles of border consisting of the Shannon and Lough Rea from Roosky to Banagher, which neither side was allowed to cross, except with a few spies. All the bridges and ferries were held to be defended on both banks by permanent forts, and no one except an undetected spy was allowed to cross them.

Then came war, followed by many small crossings of river and lake. These were effected by cyclist scouts in boats, and by mounted men either swimming or in boats with their horses swimming behind them. The small parties which crossed by these methods from both sides succeeded in blowing up railways, canal-locks, and bridges, and obtained and transmitted much accurate information of the doings of the enemy.

As the situation developed, the Scheme was worked out so that the Leinster Commander, whose original wish and intention had been to take the initiative, was delayed by the supposed slow mobilization of his imaginary main army and thus prevented from doing more than hinder the Connaught Force in its designs of invading Leinster. The invasion took place on the 15th and 16th August, near Shannon Bridge.

The only army equipment for crossing rivers which was in the possession of the Connaught Force consisted of two of the light collapsible-boat pontoons which are carried by Field Companies, R.E.; these were in charge of 3 sappers. This Force was therefore dependent on its own resources, and on those of the country as far as the limited amount of money available would permit. This put out of the question a continuous bridge over a broad, deep, and often boggy river like the Shannon.

Three rafts were therefore made out of barrels from Guinness's Brewery Depôt at Ballinasloe, decked with planks from the local saw-mill. The light pontoons formed a fourth raft; and in addition a river barge, used by a farmer for moving hay from the riverside water-meadows, was hired. A rope was stretched across the river at a point where its breadth was about 80 yards and its banks and bottom were sound; this was used to pull across rafts loaded with men holding the head-ropes of their horses, which swam alongside. A cart track, about 500 or 600 yards distant, was the only place where wagons could be brought over the boggy country to the water's edge; here the river was broader, with a slow current, but had not a sound enough bottom to allow of horses crossing. The pontoon-raft and the hay-barge decked with planks were accordingly used at this point as boats for ferrying over the transport of the Force; each took one, or sometimes two, unloaded vehicles at a trip, being poled or rowed across.

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The work was begun at 1 a.m. on the 15th August. By midday on the 16th the whole Force, except about 6 wagons, had been put across; it consisted of 2 Cavalry regiments, 200 Mounted Infantry, 1 battery of Horse Artillery, and about 50 wagons and carts. Owing to the fear of some of the planks giving way and letting the wagons damage the light pontoons, most of the wagons were taken to pieces as well as unloaded, which involved a great expenditure of time.

On the 16th the two Forces came into contact near Moate; and there was considerable fighting, ending in a rear-guard action by the Leinster Force, which retired in the direction of Tullamore. Operations were then stopped, and the two Forces marched to Tullamore and camped there.

On the morning of the 17th there was a conference at Tullamore in the Town Hall, lent for the purpose; and the troops then marched for the Curragh and Dublin, which they reached on the 18th and 19th.

The Shannon is, perhaps, the most difficult obstacle in the British Islands; and the fact that a force of the size mentioned was able to cross it, almost without the help of special troops or equipment, shows what can be done by special training in such work.

The Manœuvre Map, covering the central third of Ireland, was a great feature of the operations. It consisted of sheets of the new 4 miles to the inch Ordnance Map, which were mounted and put together without outside assistance by the Staff of the 3rd Cavalry Brigade. Sufficient copies were provided to allow of one to every man. This issue was immensely appreciated by the rank and file, who entered most keenly into the operations and discussed movements and intentions with the greatest interest.

The back of the map was covered with maxims and other useful information for the soldier; and the whole folded up between strong covers into the size of an ordinary notebook, fitting easily into any coat-pocket.

Motors, owned by members of the Motor Volunteer Corps and others, enabled the Directing Staff to cover all parts of the area of operations, which was some 50 miles by 30 or 40 in extent. Cars constantly travelled 100, and sometimes up to 150, miles in a day.

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THE CAMPAIGN IN ITALY, 1796—1797.

A STUDY OF THE STRATEGICAL INFLUENCE OF FORTRESSES IN WAR.

By CAPT. H. F. THUILLIER, R.E.

"THE Italian Campaign demonstrates in the most signal manner the vast importance of fortresses in war, and the vital consequences of such a barrier to arrest the course of military conquest. The surrender of the fortresses of Coni, Alessandria, and Tortona, by giving the French a secure base for their operations, speedily made them masters of the whole of Lombardy; while the single fortress of Mantua arrested their victorious arms for six months, and gave time for Austria to collect no less than four powerful armies for its deliverance. No man understood this better than Napoleon; and accordingly, without troubling himself with the projects so earnestly thrust upon him of revolutionizing Piedmont, he grasped the fortresses and thereby laid the foundation for his subsequent conquests. Without the surrender of the Piedmontese citadels he would not have been able to push his advantages in Italy beyond the Po; but for the bastions of Mantua, he might have carried them, as in the succeeding campaign, to the Danube."

The above passage* succinctly describes the influence which the pre-existing fortresses in Northern Italy exercised over the strategic events of that brilliant and memorable campaign. It is proposed to shew, by following the course of the operations, how that influence was exercised, and the manner in which Napoleon, then only on the threshold of his great career, made use of the conditions existing in the theatre of war and adapted them to his ends.

Opening Situation.—The Army of Italy, when the young General Bonaparte took over the command at the end of March, 1796, was stretched all along the Mediterranean littoral, from Nice to Savona, guarding the narrow space between the sea coast and the summits of the Ligurian Alps. Its headquarters were at Nice. The allied Austrian and Piedmontese armies opposed to them were distributed as follows:—Beaulieu, commanding the Austrian army of 30,000 men and 140 guns, was on the extreme right of the French; his centre

* From Alison's *History of Europe*, Vol. III., p. 120.

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was between Novi and Gavi; his right wing, under d'Argenteau, near Acqui; his left wing in rear between Lodi and Pavia. He was also in communication with the English fleet under Jervis and Nelson in the Bay of Genoa. Colli, with the Piedmontese army of 20,000 men and 60 guns, was opposite the French front and covered Ceva and Coni.

Opening of the Campaign.—Bonaparte's plan for the opening of the campaign was to thrust his force between the two armies, separate them, and defeat them in detail; and then to push his attack on the Piedmontese King and detach him from the alliance, thus leaving himself free to concentrate the whole of his forces against the Austrians.

In the beginning of April his columns began to move. Their strength was approximately 42,000 men, of whom about 5,000 were cavalry. They were in four divisions; two, under La Harpe and Meynier respectively, formed the advanced guard commanded by Massena; and the other two, under Augereau and Sérurier, formed the main body. The division of Sérurier did not take part in the first battles, and the numbers that actually crossed the mountains with Bonaparte were 28,257 men and 60 guns in the three divisions and 5,342 cavalry.* In addition to the above, about 10,000 troops guarded the lines of communication into France and furnished magazines and depôts for supplying men to the active divisions.

Montenotte.—The first movement of the French was to concentrate their forces on the extreme right. Thereupon Beaulieu moved with his centre to Genoa and thence along the sea coast to Voltri. His right under d'Argenteau was advanced to Montenotte, where it came in contact with a small French force. Bonaparte, leaving a brigade from Meynier's division to oppose Beaulieu at Voltri, immediately advanced with the remainder of Massena's command and the division of Augereau, and, crossing the Col di Cadiboni, fell on the Austrians at Montenotte and completely defeated them.

This victory opened to the French the plains of Piedmont, and, by piercing the centre of the Allies, completely separated the Austrian and Piedmontese armies; the former concentrated at Dego to cover the road to Milan, and the latter around Millesimo to protect the entrance into Piedmont. Bonaparte, in possession of a central position, resolved to attack them both at once.

Millesimo and Dego.—On the 13th April Augereau attacked the Piedmontese at Millesimo, while Massena and La Harpe moved towards Dego. In the fighting which took place that day and the next the French were successful; the Allied armies, losing many prisoners and guns, retreated; and Bonaparte moved Augereau's division forward to the heights of Monte Zemolo. Beaulieu retired

* Bouvier's *Bonaparte en Italie.*

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to Acqui, on the road to Milan, and Colli towards Ceva, to cover Turin.

Monte Zemolo.—After this battle La Harpe's division was placed to keep the remains of Beaulieu's forces in check, while the weight of the French army was moved against the Piedmontese troops. The latter were driven from the heights of Monte Zemolo, which was occupied by the French forces. This ridge was the last barring the way into the plains of Piedmont, which were then entered.

Colli, after repulsing Sérurier's division, which had attempted to turn his flank, took up a strong position in front of the French.

Bonaparte's position was now far from favourable. The Austrian army was in his rear and might easily resume offensive operations, while the English fleet in the Bay formed a standing menace to his line of communications with France by the Corniche Road. Piedmont contained numerous fortresses, some of them strong, and the French had neither heavy guns nor siege equipment wherewith to reduce them. To penetrate far into the country without securing them would have been extremely hazardous.

Mondovi.—Notwithstanding these disadvantages, Bonaparte did not hesitate to push on with vigour his attack on the Piedmontese. The latter were assailed and driven out of Mondovi with loss; on their retiring to Cherasco they were followed up, and that town also was occupied by the French.

Treaty with the Piedmontese and Acquisition of their Fortresses.—At this the Court of the King of Sardinia* began to feel much alarm for the safety of their capital, Turin, and proposed negotiations for peace. Bonaparte however insisted that as a preliminary the fortresses of Coni, Ceva, and Alessandria, with their artillery and stores, should be given up to him, and, after some demur, this was agreed to on the 27th April. A treaty of peace was then made between the King of Sardinia and the French Republic, by which Nice, Savoy, and part of Piedmont were ceded to France, and free passage through the former's kingdom granted to the French troops.

The advantages gained by this treaty and the possession of the fortresses were of enormous advantage to Bonaparte. By them he gained a great quantity of artillery and stores and a firm and solid base in Piedmont; also a new and direct line of communication into France, safe from the molestation of the English fleet. Having thus secured his rear he was able to turn his undivided attention to the destruction of the Austrians, and to enter with confidence on that brilliant campaign, which resulted in the conquest of all the states of Northern Italy and ended in the following year in the dictation of the victor's terms almost within sight of the Austrian capital.

The valuable effect that may be exercised by fortresses in a purely

* Sardinia and Piedmont were then united under one crown.

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aggressive campaign is here illustrated. How to avail himself of this effect no commander has known better than Napoleon. An examination of his great campaigns of conquest in Germany and Austria shews that in every case, even when he was advancing from victory to victory, he invariably took care to secure his line of communications and to form advanced bases and points of support by taking and holding existing fortified places or by constructing new ones. For this purpose in the Marengo campaign he prepared an entrenched camp at Stradella; in the Ulm campaign he formed reserve camps at the fortresses of Strasburg and Mainz, and fortified Neu-Brisach and Huningen; in the Austerlitz campaign he chose Augsburg as his advanced magazine and fortified it, and when he advanced to the Inn he used the fortress of Braunau for the same purpose; the same proceedings may be observed in the Jena and Eylau campaigns. "This method of ensuring the reinforcement of his army by the establishment of direct reserves, and of securing his base by fortifying the strong places, is one of those precautionary methods which this audacious but careful general always took.*

Renewal of Operations against the Austrians.—On the completion of the treaty Bonaparte lost no time in pursuing the discomfited remains of Beaulieu's army, which had retired behind the Po in the hopes of covering the Milanese territory. Being reinforced by 8,000 men of the corps of Kellermann, he crossed the Po at Placentia, and, having forced the Grand Duke of Parma to capitulate, marched towards Milan, which was entered on the 15th May after a severe combat at the bridge of Lodi on the Adda River, Beaulieu retiring behind the Mincio.

Advance to the Adige.—After a slight delay at Milan Bonaparte resumed his operations against Beaulieu, and on the 28th May entered Brescia in the territory of the Venetian Republic. Beaulieu took up a defensive position on the Mincio, and garrisoned Mantua with twenty battalions of his best troops. Bonaparte, however, at once attacked and drove Beaulieu from his position, and sent Massena's command against the town of Verona, which it entered on the 3rd June. Thus Bonaparte secured the line of the River Adige, to the possession of which he attached great importance. Beaulieu retired and entrenched himself at Reveredo in the mountains of the Tyrol, where Bonaparte was unable for the present to follow.

Siege of Mantua.—The fortress of Mantua, strong by reason of its natural and artificial defences, was so situated that its possession was necessary to the French in order to secure their conquests in Lombardy and also essential to a further advance into the Tyrol. The latter could not be attempted if the garrison of Mantua were in a position to threaten the French communications; nor was

* Yorck von Wartenburg's *Napoleon as General*, Vol. I., p. 209.

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Bonaparte's army of 45,000 men strong enough to permit of the advance being made and at the same time of forces being detached for the blockade of Mantua (for which at least 15,000 men would be required) and for the safeguarding of the line of communications. Nothing remained therefore but to reduce Mantua before proceeding further; accordingly immense efforts were made by Bonaparte to capture it, and by the other side, who fully realized its importance, to effect its relief.

At this juncture the Austrian Government detached Wurmser from the Army of the Upper Rhine with a force of 30,000 men to relieve Mantua and restore affairs in Italy.

Bonaparte, knowing that Wurmser could not arrive before the middle of July, utilized the interval to overrun Lower Italy, leaving 15,000 men before Mantua and 20,000 on the Lower Adige to cover the blockade. He returned from this excursion in time to meet the onset of Wurmser.

First Campaign for Relief of Mantua.—The operations which ensued are of the most fascinating interest. The judgment, daring, and energy shewn therein by Bonaparte were such that the campaign of 1796 alone, if he had fought no other, would have placed him among the greatest of modern commanders, and in none of his later and more ambitious campaigns were these qualities displayed in greater measure.

The junction of Wurmser's force with that of Beaulieu brought the Austrian total up to 60,000. To meet this Bonaparte altogether had but 55,000, of which 15,000 were engaged on the siege of Mantua and 10,000 on the line of communications and garrisons in the conquered provinces, leaving only 30,000 available for operations in the field.

Fortunately for him the Austrians, acting under the direction of the Aulic Council, divided their forces, Wurmser with 40,000 men proceeding down the eastern side of the Lake of Garda on to Verona, while Quasdanovitch was despatched with 20,000 round the upper end of the lake to descend by the western side upon Salo. If these two forces could succeed in enclosing the French army they would infallibly crush it by their great superiority of numbers.

Without the slightest hesitation Bonaparte raised the siege of Mantua on the 31st July, the cannon being spiked and the stores of the besiegers thrown into the lake; and then concentrated his army, including the force lately employed on the siege, at the lower end of the lake, where it was between the two advancing Austrian armies and in a position to attack and defeat either in detail. Massena's command was at Rivoli between the Adige and the eastern shore of the lake, but was retreating before Wurmser. The French army on the next day (1st August) moved swiftly against Quasdanovitch on the western side, defeated him, and drove him back towards the mountains. Meanwhile Wurmser, pushing Massena before him, advanced down the

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eastern side and entered Mantua the same day. The following day he crossed the Mincio and advanced against the French, with a view to enveloping them while Quasdanovitch again resumed the offensive.

Castiglione and Lonato.—Bonaparte, with whom Massena's command had now affected a junction, immediately faced his army round; and on 3rd August vigorously attacked Wurmser at Castiglione and Lonato, completely defeating him.

Continuing his vigorous movements, he again drove Quasdanovitch northwards; and, turning once more on Wurmser, engaged him at Medole on 5th August and drove him beyond the Mincio. On his further advance to Peschiera and Verona, Wurmser retired again to the Tyrol and resumed his former station at Reveredo. So ended the first campaign for the relief of Mantua.

The result had been that Wurmser had been driven back with the loss of nearly 20,000 men and 60 pieces of cannon, and the spirit of his soldiers had been broken by fatigue and defeat. On the other hand he had interrupted the siege of Mantua and supplied it with a garrison of fresh troops. Moreover the French had been obliged to sacrifice the whole of their siege train, and the town could now only be taken by the slow process of blockade.

We cannot but admire the judgment and resolution of Bonaparte in making up his mind to this sacrifice. It is an example of the manner in which he always held fast to his ultimate aims and set aside secondary objects. In this case the immediate, though secondary, object was the capture of Mantua, but the ultimate aim was, as it must always be in war, the defeat of the enemy's main forces. The concentration of the whole of his available force upon the latter was undoubtedly the right course, and an examination (which space does not permit of here) of all his possible alternatives would shew that it was the only judicious one.* None the less it is only a master mind which can clearly distinguish the great from the minor issues, and unerringly select amid the stress and turmoil of war the correct course to adopt, and which further has the resolution to follow it come what may, even when it entails a great sacrifice.

After this struggle the troops on both sides remained in a state of repose for three weeks. Bonaparte did not attempt to collect a second battering train for the siege of Mantua, but contented himself with a simple blockade; in maintaining this during the autumn months his troops became extremely sickly from the pestilential atmosphere of its marshy surroundings.

Wurmser employed himself assiduously in reorganizing and recruiting his forces, while Bonaparte received considerable reinforcements from the army of Kellermann and the interior of France.

* For an examination of the possible alternatives open to Napoleon, see *Napoleon as General*, by Count Yorck von Wartenburg, Vol. I., p. 69.

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Second Campaign for Relief of Mantua.—At the end of August the numbers on each side were nearly equal, both amounting to nearly 50,000 men. Wurmser, under the instructions of the Aulic Council, began to put into operation a new plan of attack on the French; this consisted in leaving 20,000 men under Davidovitch to guard Reveredo and the valley of the Adige, and descending himself with 30,000 by the gorges of the Brenta to Bassano so as to reach the plains of Padua. In fact he was again about to commit the error of dividing his forces into two columns while Bonaparte occupied a central position equidistant from both; with this difference, that instead of a lake, they had a mass of impassable mountains between them.

Bonaparte at the same time assumed the offensive by ascending the Adige. Foreseeing the possibility of a descent upon Mantua during his absence, he left Kilmaine with 3,000 men to occupy Legnago and Verona, and he himself with 30,000 ascended the Tyrol by the valley of the Adige and the road on the western side of Lake Garda. On the 4th September the Austrian positions were attacked and their troops driven headlong through Reveredo, and again followed up towards Trent, which place was entered by Bonaparte the next day, while the discomfited remains of Davidovitch's corps retired behind the Lavis.

Wurmser, on hearing of this, pushed on the faster with his force, with the intention of seizing Verona, raising the siege of Mantua, and preventing the return of Bonaparte into Italy. Bonaparte, who received by treachery intelligence of these designs, left the division of Vaubois alone in the Tyrol to make head against Davidovitch, and himself with 24,000 men descended the defiles of Brenta to attack Wurmser before he could carry out his intention. Wurmser's rear guard was caught up and driven back at the gorges of Val Sugana, and his main body routed by the divisions of Massena and Augereau at Bassano. During the confusion of this defeat the Austrian divisions got themselves separated from each other; Quasdanovitch with 3,000 men was thrown back towards Friuli, while Wurmser with 16,000 took the road to Mantua. The latter was vigorously followed up by the French, and, after several stubborn actions, was driven within the walls of Mantua and shut in there by the end of the month. There were thus left only 15,000 of the 50,000 with which the Austrians had commenced the campaign, namely 12,000 under Davidovitch, who had taken refuge in the defiles of the Tyrol, and 3,000 under Quasdanovitch at Friuli. So ended the second Austrian attempt to relieve Mantua.

After these exhausting efforts both parties remained in inactivity for a considerable time, during which the Austrians were energetically employed in repairing their losses, and the French in drawing forces from the other side of the Alps.

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Third Campaign for Relief of Mantua.—By the end of October a new Austrian general, Alvinzi, who had assumed command of the troops in Friuli, had assembled 40,000 men under his standards, while the corps of Davidovitch was raised to 18,000 men.

To oppose this mass Bonaparte had 12,000 men under Vaubois on the Lavis in front of Trent; 20,000 on the Brenta and the Adige, observing Alvinzi; and 10,000 guarding the lines round Mantua.

On the 1st November Alvinzi attacked the French opposed to him, but was repulsed. On the same day Davidovitch drove back Vaubois to the plateau of Rivoli, and this necessitated the retirement from before Alvinzi of the main body under Bonaparte. Alvinzi followed up the latter and gained a victory over him at Caldiero on the 11th November.

Bonaparte's position was now desperate. His army was it is true in a central position, the main body being at Verona, and the corps of Vaubois at Rivoli keeping back Davidovitch. But their numerical inferiority was very great.

Arcola.—At night on the 14th November Bonaparte left Verona as if in retreat, but turning to the left marched on Ronco on the Adige, where he crossed the river and proceeded to attack Alvinzi's force in flank by the village of Arcola. After three days' desperate fighting among the marshes and causeways surrounding that place Alvinzi was forced to retire to Vicenza without having effected a junction with Davidovitch, who had pressed back Vaubois towards Verona.

Without losing an instant Bonaparte turned on Davidovitch and forced him to retire into the Tyrol.

The third attempt to relieve Mantua thus ended in failure, though the losses of the victors were nearly as great as those of the vanquished. The results also were less decisive, and, though Mantua had not been relieved, Wurmser had taken advantage of the confusion and interruption of the blockade to make sorties and to introduce convoys of provisions which enabled him to maintain his position longer.

Negotiations for an armistice were now set on foot, but came to nothing. Both sides obtained large reinforcements of men and made great preparations for a renewal of the contest.

Fourth Campaign for Relief of Mantua.—At the beginning of January, 1797, Bonaparte had 46,000 men under arms, of whom 10,000 blockaded Mantua and the remainder were on the line of the Adige from the Po to Monte Baldo.

The Austrian plan again consisted in dividing their forces; Alvinzi himself with 35,000 men advanced to the Upper Adige, and on the 12th January attacked the French at Monte Baldo; while a subordinate force of 15,000 advanced from Bassano by the plain of Padua with a view to raising the siege of Mantua, and on the same day drove in the French vedettes towards Legnago.

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Bonaparte, who received intelligence of the plan, moved to Rivoli with the whole centre of his army to support Joubert, who was there struggling with immensely superior numbers.

Rivoli.—On the following day was fought the battle of Rivoli, in which the French arms achieved a decisive and glorious victory. On the same night Bonaparte took Massena's division and hastened with the utmost speed to the assistance of the troops on the Lower Adige. He arrived on the evening of the 15th in the neighbourhood of Mantua in time to prevent a junction between Wurmser and the troops under Provera who had approached to raise the siege. On the 16th severe fighting took place, after which Wurmser was forced back into Mantua and Provera was surrounded by superior forces and compelled to surrender with 6,000 men.

Thus in three days, by his admirable dispositions and the extraordinary activity of his troops, did Bonaparte not only defeat two Austrian armies of much greater force, taken together, than his own, but took from them 18,000 prisoners, 24 standards, and 60 pieces of cannon. Such was the loss of the Austrians in killed and wounded that they were totally disabled from keeping the field, and the French were left in undisputed possession of the whole peninsula.

The remains of Alvinzi's corps retired in opposite directions, one part towards Trent and another towards Bassano. Bonaparte followed them up vigorously, and finally drove them with further loss beyond the Tagliamento.

Fall of Mantua.—This was the last effort of which Austria was capable, and Mantua did not long hold out after the destruction of the fourth army destined for its relief. The half of its once numerous garrison was in hospital; they had consumed their horses; and the troops, who had been for months on half rations, had nearly exhausted all their provisions. Wurmser therefore capitulated, the siege having lasted since the middle of June, a period of seven months.

Campaign against Papal States.—Having achieved this conquest, Bonaparte turned against Rome, and, after completely defeating the Papal troops, concluded the treaty of Tollentino, on terms most humiliating to the Holy See.

"Such was the campaign of 1796, glorious to the French arms, memorable in the history of the world." *

Invasion of Austria, 1797.—Early in the following spring Bonaparte resumed offensive operations against the Austrians, who had raised a fresh army under the Archduke Charles for the defence of their country. Within a month he had defeated the latter, driven him across the Julian Alps and through Carinthia, and concluded an advantageous peace at Leoben, within a couple of marches of Vienna.

* Alison.

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It can hardly be doubted that but for the obstinate defence of Mantua this operation would have been carried out in the autumn of 1796. The necessity for taking that place and completely securing his rear caused a delay to Bonaparte of over six months.

It is true that the possession of this fortress did not save the Austrians from ultimate defeat. That however does not prove the uselessness of fortresses, but only shews the limitations in their effect. The four great efforts made to relieve the place and defeat the French while they were still tied by the necessity of blockading it were sufficient for their purpose under ordinary circumstances. One of the reasons for their non-success was the pernicious habit of the Austrians of dividing their forces in the presence of a concentrated and enterprising enemy. But, with their superiority in numbers, even these tactics would have been successful against any one but Bonaparte. It was only by the most extraordinary vigour and boldness that the latter managed to defeat them. The strategic gain brought about by the defence of Mantua was very great, but the external forces failed to turn it to advantage.

This illustrates the maxim, which can be proved in countless instances from history, that fortresses cannot take the place of an efficient field army. Nor can they by themselves arrest the advance of a victorious invader. The utmost that can be expected of them is to delay, check, and weaken the adversary, and thus afford time and opportunity for the defender to organize and assemble his field armies, by whose operations alone can ultimate victory be gained.

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WITH THE PONTOON TROOP IN NATAL, 1899—1900.

By Bt. Colonel J. L. Irvine, R.E.

PART I.—COLENSO.

On the mobilization of the Army Corps for South Africa in October, 1899, it was not anticipated that bridging operations in Natal would be necessary, but full provision was made for the passage of the Orange and Vaal Rivers. Every available pontoon and article of bridging equipment was sent to the seat of war from Chatham, Aldershot, and Woolwich; and "A" Pontoon Troop, R.E., was brought up to the regulation war strength and despatched to South Africa. No sooner however had the invasion of Natal and the investment of Ladysmith taken place than it was realised that the force advancing to the relief of that town must be provided with means for crossing the Tugela, which, from its rise in the Drakensberg at Mont aux Sources until its discharge into the Indian Ocean, is a rapid, uncertain river, flowing between steep banks, and liable during the rainy season (November to March) to rapid and sudden alterations of level.

Accordingly, "A" Troop, under my command, on its arrival at Capetown, was at once ordered to re-embark and proceed to Natal; the number of pontoons with it was increased from 16 to 30 and superstructure was added in proportion. Disembarking at Durban on the 28th November we proceeded with the equipment, in three trains, to Pietermaritzburg. The men were all accommodated in open goods trucks, each of which was fitted with benches to seat 60 men.

The journey up country was most delightful after our long sea voyage, as the train went snorting and puffing round sharp curves and up steep gradients through the bold and picturesque scenery of Southern Natal. In the low lands near the coast we passed through semi-tropical vegetation with plantations of bananas, pineapples, and orange trees, while higher up were the bare flat-topped hills and the grass-covered slopes of the veld. The whole country was intersected by deep ravines and dongas. One of the most noticeable of these, passed soon after leaving Pinetown (where the Princess Christian Hospital was afterwards established) was Krantz Kloof, a deep wide valley, hewn by nature out of the hard rock, and with almost precipitous sides which rise hundreds of feet above the Umgeni River flowing quietly at their base.

We met with great enthusiasm and hospitality all the way. At Durban the inhabitants loaded the men with cigarettes, bananas, bread, buns, etc., all most acceptable to them after ships' rations. On

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our way up country, when the train stopped to water the engine, committees of ladies brought tea round. All hailed the arrival of the troops with gladness, for the nightmare of the threatened Boer attack on Pietermaritzburg, and possibly too on Durban, was still fresh in their thoughts. At Pietermaritzburg, after dinner had been served out and disposed of, a committee of ladies, many of them English refugees from Johannesburg, came round and distributed lemonade, tobacco, pipes, matches, etc., to the men; and they also provided writing desks, note paper, envelopes and stamps, all of which were very much appreciated.

Our stay at Maritzburg was longer than we expected, but it enabled us to add to our equipment all articles which the special circumstances of the case required. We provided ourselves with twelve Weldon trestles, steel cables for suspension bridges, travellers and other gear for aerial tramways, extra rope and cordage, differential tackles, additional blocks, and a variety of small stores. Experiments were also made as to the best method of carrying the pontoons and superstructure on ox wagons; and after perilous journeys over the worst ground in the neighbourhood, it was decided to carry three sections of pontoons and one and a-half bays of superstructure on each wagon.* This was a cumbersome and topheavy arrangement, but it was necessary in order to reduce transport; and, beyond giving a great deal of extra labour in packing and unpacking wagons, answered very well during the Campaign. The weight of pontoons and superstructure was approximately 4,500 lbs., which, with the weight of the ox wagon (30 cwt.), made the total load about 8,000 lbs. While at Maritzburg we also drew the horses for N.C. Officers, and a very rough lot they were—Colonial or Argentine ponies—some entirely unbroken; and also our water cart and mules.

At last orders to proceed to the front arrived; and after a busy day entraining our equipment and horses, and returning all kits, spare blankets, etc., to store, we started in three trains at 10.30 p.m. on the 10th December and reached Estcourt at 6 a.m. next morning. We then had a very busy day detraining our equipment and packing it on the ox wagons, which, with their teams, were here supplied to us. Our first experience of ox transport came next day, when, on parading at 4.30 a.m., we found that neither conductors (Colonials) nor drivers (Natives) appreciated the value of military punctuality,

* Some of our pontoon wagons were sent out from England in a different ship from ourselves, and had not arrived at Capetown when we left. We only had 13 pontoon wagons with us, so had to provide transport for 17 other pontoons and also for the trestles, stores, etc.

In the British service each wagon carries a bi-partite pontoon (capable of being separated into two sections), one bay of superstructure (*i.e.*, the material to make the roadway between two pontoons), and a few other stores.

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though my best endeavours had been spent the previous evening in instilling this virtue into the chief conductor. However, by dint of hustling we at last got them all off at 5 a.m. and reached the rendezvous, where we were soon joined by our escort of the 13th Hussars. We made a goodly column in ourselves with our trestle and thirteen pontoon wagons, each with a span of ten oxen, and fifteen ox wagons with their teams of sixteen bullocks, and one water cart with four mules. We covered three quarters of a mile in column of route when the oxen kept their proper distances; but as this is not the custom with these animals, we soon lengthened out to about a mile. This was the first time I had seen ox transport and I was very much impressed with the quiet patient manner in which these beasts work and with the energy and goodwill of the native drivers and leaders. The drivers use their whips with great dexterity, and, with most uncouth sounds, urge on the oxen to renewed exertion. One soon learns the use of "Hambake" (go on) and "Ann hou" (stop), and with these two expressions one can get on fairly well as long as it is a case of "follow my leader" or formation in line; but when more difficult manœuvres, such as formation in column of sections, are attempted, the native, whose brain is incapable of great understanding and who does everything at a run regardless of any obstacle in his way or expostulations from the "baas," generally brings about rather amusing, if at the time somewhat exasperating, complications.

It was a twelve-mile march to Frere; owing to the heat, it was a very trying one to the men, who were not yet acclimatised and were moreover carrying their greatcoats and kits. We arrived there at 9.30 a.m. and settled down into camp near the scene of the armoured train disaster a week or two before.

At 9 a.m. next day we marched to Chieveley under an escort of two squadrons of Bethune's Mounted Infantry. The Naval guns had been bombarding the Boer position on the hills above Colenso for the two days previous; but never a shot did the enemy's artillery fire in return, nor were their infantry seen in any of the trenches. Was it possible, as some averred, that the Boers had retired? Hardly so, but we were to know the next morning, as an attack had been decided on. A Council of War was held at 5.30 p.m., after which I was informed that the Pontoon Troop would not be required next day and would be held in reserve, though possibly it might be wanted in the afternoon for the passage of the Transport.

Friday, December 15th, was a momentous day for the Natal Army. The infantry marched out at 4.30 a.m., and a quarter of an hour later we moved off and took up our position in rear of the low hill from which the Naval guns had lately been busy bombarding the enemy's lines. The Boer position extended for about three miles in our front, and consisted of an amphitheatre of hills, rising gradually higher and higher, of which the little village of Colenso might be

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considered the arena. Their right rested upon Grobelaars Kop and their left on the formidable-looking Hlangwane Hill; beyond these two flanks the hills stretched east and west in an unbroken line and formed an impassable barrier. In front of the whole position, but curving in rear of Hlangwane, flowed the swift Tugela River, spanned close to Colenso village by the road bridge. The Ladysmith road ran north from the road bridge over Grobelaars Kop. Everywhere the active enemy had dug shelter trenches, on which our guns seemed to have produced small effect. Right in the centre of the "front row" of the amphitheatre rises Fort Wylie, a low but commanding kopje on which we had built a small work when it had been considered possible for us to hold Colenso. All along the river bed and up the sides of Hlangwane the country was covered with mimosa bush. On our side the ground sloped in a gently undulating and open plain, without cover of any description, from the high ground at Chieveley railway station to Colenso village, round which the Boers had placed their advanced trenches, and to the river. A stronger position than the enemy held it was impossible to imagine, but everywhere along the river it was the same thing, the same impenetrable barrier of almost inaccessible hills. Their weak point was Hlangwane Hill which was on our side of the Tugela. The Boers did not hold this in any great strength, as they do not like to fight with their backs to a river; but they garrisoned it with 800 picked shots and two or three guns, and it was naturally so strong with its steep slopes, its mimosa bush, and its deep and treacherous dongas, that we did not make any serious attempt to storm it. As we learnt afterwards the Boers had omitted no precautions in strengthening their position; everywhere along the faces of the hills were deep and numerous trenches kept cunningly below the sky line. The Ladysmith road was crossed by elaborate earthworks, and as the road curved upwards its sides were hollowed out into glorified rifle pits from which a murderous fire could be brought to bear on an advancing foe. The guns were most skilfully placed and carefully hidden, and protected by strong epaulments.

How little did we think of all this as our troops, with their usual British confidence, advanced towards the river. I took up a position on Naval Gun Hill, almost in rear of the centre of the attack, and watched the movements with intense interest. On the left was General Hart's brigade making for the drift, and on the right General Barton's. General Hildyard's brigade in the centre moved on Colenso village and the road bridge, while General Lyttelton's brigade remained in reserve. On the right the cavalry and mounted infantry made a wide detour to try and turn the Boer left on Hlangwane. Haze and distance made it difficult to see what was taking place on the flanks, but immediately in front of us Hildyard's brigade was slowly advancing in single lines about sixty or eighty

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yards apart and with six to ten paces interval between the files, an excellent formation.

Our guns opened fire at 5.25 a.m., but for nearly an hour not a shot was sent in reply. A thought of defeat never entered our minds. Turning to an officer standing near me, I asked him what he thought we should be doing in the afternoon. "Doing," he replied with surprise, "why of course we shall be taking tea in Ladysmith"; and this was the feeling that pervaded the whole force.

A regular roar of musketry fire burst from the Boer lines at 6.10 a.m., dispelling in a most complete manner the theory that the position had been evacuated. The smokeless powder, and the deep trenches in which the Boers were hidden, made it almost impossible to locate their fire; but one could see that the enemy were in their trenches at Fort Wylie. Our guns poured in shell after shell, but no effect appeared to be produced and the fire of the Mauser rifles went on as merrily as before. The Boer guns joined in the fray, from Grobelaars Kop, the Ladysmith road, the kopjes near Colenso, and Hlangwane Hill; but amid the roar of guns and the crack of the rifles a new sound was heard, a metallic bang, bang, bang, quite unlike the explosion of any other powder; we soon learnt to know this as the sound of the Vickers-Maxim gun (afterwards christened the "Pom-pom"). And so the fight went on, outbursts of rifle fire alternating with the deep booming of the guns. At 7.45 a.m. the fury of the battle seemed to reach its climax. At 9 a.m. heavy firing burst out on our left, and our guns and infantry fell back; but surely this could be only temporary, for a few minutes later one saw the Boers galloping down from one of the near kopjes. At last apparently our fire was beginning to tell, and our Naval guns turned their attention to these fast moving horsemen; but they dodged the shells with complete success. The moment a shell had burst half a dozen left their cover and galloped across the open space till they reached the shelter of Fort Wylie; boom went the gun again, and another half dozen left their cover and were lost to view; and it was soon apparent from the redoubled fury of the rifle fire that these men were not in retreat but were reinforcing the firing line. Soon rumours of disaster began to reach us; a wounded man of the Dublin Fusiliers told us how they plunged into the river and, finding it "ten feet deep," half the leading company were swept away and drowned; the report of the drowning was confirmed by subsequent arrivals, who however reduced the number to half a dozen; another wounded man told of the "bloody butcher's shop" they went into; and worse still, a rumour crept round that the 14th and 66th Batteries of artillery had suffered heavily.*

* Later we heard of the loss of the guns and of the gallant attempt made to recover them.

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The stretcher bearers and ambulances soon began to arrive at the Dressing Station with their melancholy burdens, and the medical officers were hard pressed to attend to the wounded, whose sufferings were accentuated by the great heat. It was bad enough for us who had nothing to do but to look on quietly; what must it have been for the poor wretches lying wounded on the battlefield, or, if able to walk, toiling wearily back from the fighting line, leaning heavily on a comrade's arm. The more serious cases were brought back on stretchers by men of the Stretcher Bearer Corps, mostly refugees from the Transvaal, who had specially enlisted for this purpose; and right well they did their duty.

At 11.30 a.m. rumours of a retirement reached us and an hour later we got orders to return to our former camping ground. The retirement was carried out in a perfectly quiet and methodical manner, and reminded one most forcibly of a return to camp after a field day at Aldershot, only on a more realistic scale. A feeling of gloom and disappointment pervaded all ranks, and this was more marked next day when the actual losses were known and we heard of the valuable lives that had been sacrificed. The only relieving feature for the remainder of the day was some violent cheering which took place about 9 p.m. It was caused by the return to camp of the Colonel of the Inniskilling Fusiliers, who up till then had been missing. Our only comfort was that, in spite of the withering fire to which our troops had been exposed, they had all behaved according to the best traditions of British soldiers; and although forced to retire owing to the unexpected strength of the position, they were confident that before long they would turn the tables on their foes.

An armistice for the burial of the dead was proclaimed next day, and this solemn rite was performed in a silence that contrasted most strangely with the roar of the previous day's battle. The Boers boasted that their losses did not exceed two killed and thirty wounded; however much of an exaggeration this may be, it is probable that their casualties were not heavy, for their firing line was difficult to locate and they were all concealed in deep narrow trenches, offering a very small target to our artillery. Our men, on the other hand, had to advance over perfectly open ground, and during both the advance and the retirement they were exposed without cover to the merciless fury of the enemy's fire.

The Boers busied themselves all day deepening and extending their trenches, and making a gun epaulment on one of the hills to the west of Grobelaars Kop, where they brought a gun into position to bombard our camp next day. In this evil design they were however frustrated, for, on the termination of the armistice at midnight, part of our force (among them the Pontoon Troop) marched back to Frere, while those remaining at Chieveley retired behind the railway

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line out of range of the guns. It was a glorious night for a march, with an almost total eclipse of the moon.

The next month was a period of comparative inaction. For the first fortnight the heat was intense, and the Blau-krantz River, from which we drew our water supply, gradually dwindled away and eventually ceased running altogether, causing some anxiety ; but the pools furnished enough to keep us going, though the water was of a very inferior quality, and wells were dug wherever there were any signs of the existence of a spring. At last the rains came with a vengeance and the dried-up Blau-krantz soon became a roaring torrent.

PART II.—SPION KOP.

In the meantime the 5th Division, under Sir Charles Warren, had arrived at Estcourt. On the 9th of January, 1900, it marched to join Sir Redvers Buller's force at Frere. This was unfortunately one of the wettest days we had experienced ; the rain came down in one ceaseless rush from early in the evening of the 8th until the afternoon of the 9th ; the drift over the Blau-krantz near the railway station was almost impassable, and a large crowd collected to watch the efforts of the native drivers to get their mule or ox teams through the roaring waters, against the rush of which they were barely able to stand up. By the following morning the rain had cleared off. The country was still very soft and sticky, but it improved during the day. It is extraordinary what a few hours of the hot African sun will do in drying up the rain-sodden veld.

The whole force, with the exception of General Barton's brigade at Chieveley and a small garrison at Frere, commenced a fresh advance towards the Tugela. Leaving early on the morning of the 10th of January, the mounted troops and General Lyttelton's brigade pushed forward and eventually occupied without resistance the heights overlooking Potgieter's Drift. The troops from Chieveley followed, and in the evening the 5th Division and the remainder of the troops at Frere, the garrison excepted, moved off. We were ordered to rendezvous at 5.45 p.m. at the "nek" on the Springfield road, but it was three hours later before we started, a block having occurred at the drift below Pretorius' farm near Springfield.

On the way to the rendezvous three of our wagons got imbedded up to the axles and had to be dug out, the ground being very soft and treacherous after the rain ; this was not the only experience of the kind we had, as it recurred two or three times during the march. An incident that enlivened the long wait was the arrival of a "steam sapper," which came snorting at full speed up the hill, scattering men right and left, spitting out flame and fire and looking in the semi-darkness like some inhabitant of the nether regions. It was possessed with good intentions and was anxious to render service by hauling

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wagons across the drift; but unfortunately in this instance good intentions did not act as paving stones, and no sooner had it reached the top of the hill than, coming across a soft place in the road, it ignominiously imbedded itself and took no further part in the show. At last at 8.45 p.m. we moved off, getting along slowly and with constant stoppages. It was very dark, and before long we were overtaken by a heavy thunderstorm, which soaked to the skin everyone without greatcoats and made the roads so slippery and muddy that marching was very difficult and most laborious. The march was interrupted by constant stoppages and at last, about midnight, came to a halt altogether. After waiting for about an hour I rode forward to ascertain the cause of the delay and soon found that the drift over a small spruit was the difficulty. Never have I seen such amusing confusion; on the right-hand side was a deserted G.S. wagon, half tilted over and with its off fore wheel in a deep hole; on the left was a bullock wagon with its near wheels firmly imbedded in the mud, from which a double team of oxen, amid the cries of the drivers, the vociferations of the conductors, and the loud cracking of the whips, was trying unsuccessfully to extricate it; in the middle, between these two, was a narrow tongue of hard ground, towards which carts and wagons were pressing from all sides, doing their best to jostle each other out of the way. One Officer and one Conductor were particularly loud in their protestations, and if a ready command of forcible language had been a password, they would not have been kept long waiting. The Officer was in charge of ammunition carts and he kept on informing the crowd "My regiment is fighting at the front and I'm d ——d if they shall run short of ammunition"; this was so often repeated that we really began to think that there was fighting going on. His efforts were ably backed up by the Conductor, and by dint of their united energy the ammunition carts were at last brought up to the drift. But, alas for the disappointments that attend our best endeavours, the second cart that tried to cross, instead of keeping quite straight, went too much to its right and got firmly imbedded in a hole, from which no efforts of the mules could draw it; and the passage then became completely blocked. Our poor friend was absolutely crestfallen at this contretemps when victory seemed so near. Seeing it was hopeless to get our wagons over that night, we made ourselves as comfortable as the wet ground would allow us and tried to snatch a brief sleep.

At the first glimmer of dawn I explored the spruit and soon found a spot where a pontoon bridge could be put in; it was quite a narrow place, just under fifteen yards (*Photo* I.). Our wagons were first passed over and then the bridge was opened to the public and used throughout the day. On the completion of the bridge, half the Troop went forward to the next spruit, a mile or so further on, and formed a bridge there; the 17th (Field) Company, R.E., was also working at this

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drift. During the morning, with the help of an infantry working party, the wagons that had stuck at the first drift during the night were unloaded and drawn out and the holes filled up with stones, the traffic then resuming its ordinary course.

By 4 p.m. we had taken up both bridges and received orders to join General Talbot-Coke's brigade at Springfield bridge; so we pressed on and got into his camp at 9.30 p.m., having some difficulty in the dark in finding our proper place.

Next morning at 9 a.m. we got orders to advance. Having collected our oxen, which were out grazing, and packed our baggage, we moved out of camp; and halting at the bridge (which by some oversight the Boers had not destroyed) until the advance guard was ready, we marched to join Sir Charles Warren's force at Springfield, four miles or so further on. Here we again found a drift causing delay, so put in another bridge for the passage of the infantry.

During the next three days comparatively little was done beyond reconnoitring; but supplies were pushed up to the camp at Spearman's Hill, where Sir Redvers Buller and the Headquarter Staff had joined General Lyttelton.

On the 16th January at 4 a.m. the Pontoon Troop moved out about 2½ miles and formed up for the day, taking up a position unseen from the Boer position on Spion Kop. Leaving again at 5.30 p.m. we were very cleverly piloted by a guide, who kept us behind folds of the ground until, an hour later, we halted behind a nek overlooking the Tugela. Soon after 8 p.m. an advance took place, the troops having come up in the meantime; two companies of the Queen's led the way, followed by a squadron of the 13th Hussars and the Pontoon Troop, and then the remainder of the Division. There was a track down the side of the hill, difficult to follow in the dark and rather rough; but with the exception of one wagon, which, leaving the road, went into a hole and turned over, we got safely down the hill and on to a low-lying piece of flat ground. Here we were suddenly thrown into confusion by some cavalry from Spearman's Hill, sent to join us, cutting into the head of our column. After some little delay and a good deal of forcible language, we got on to the right track again, and formed up about 12.30 a.m. behind one of the hills overlooking Trichardt's Farm* on the banks of the Tugela. Here we snatched a few hours' sleep.

At 6 a.m. on the 17th I accompanied Sir Charles Warren and his Staff to the crest of the hill immediately in our front. From here we got a grand view of the country: on our right front were the bold and precipitous outlines of Spion Kop, gradually lowering until they reached two conical hills which overlooked Potgieter's Drift and

* Mr. Trichardt was a Dutchman who had thrown in his lot with the Boers.

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acted as sentinels to the Boer position on Brakfontein; almost in rear of Spion Kop, and running out north, was the flat-topped spur of 'Ntabamnyama, also ending in a little conical turret of rock; below again were other ranges of hills, while at our feet lay Trichardt's Farm, apparently deserted, and the quiet flowing Tugela. How peaceful it looked on this beautiful day in the early morning light; the only sign that we were not the sole occupants of the country was the appearance of a single figure moving slowly towards Wright's Farm on the north bank of the river, showing that that at least was inhabited. We did not realise that we were on the eve of one of the hardest and most deadly struggles of the campaign, wherein our officers and men needed all that mettle and courage which is so pre-eminently their birthright. We then moved down nearer to Trichardt's Farm; and after a careful reconnaissance, decided on a position for a pontoon bridge, about 300 yards below the farm (itself 200 yards from the river) and just below an island that would give holding ground for the anchors.

The Pontoon Troop was ordered to advance, the artillery posted on the heights, and the West Yorks told off as a covering party and to line the south bank of the river. These preparations made, we undertook the task set us with some apprehension of its difficulties.* At 8 a.m. the wagons formed up and were unpacked under cover of the farm buildings, and half a battalion of the Devons helped us in the work of getting the equipment to the river. A brisk musketry fire burst out from Wright's farm, and was replied to by our covering party and by our artillery on the hills. The enemy soon found it too hot for them, and left hurriedly after about a quarter of an hour's firing; not, however, before they had done some damage, for Private Perry of the Devons was shot through the heart as he stooped to lift a pontoon. The men were told off into two parties, one under Lieut. J. W. Skipwith arranging for a ferry, the other under Lieut. R. Ommanney taking charge of the arrangements for the bridge. While superintending the unpacking and portage of the material a message was brought to me that the banks were nearly impracticable, being 25 feet high, almost perpendicular, and with an outcrop of rough rock. This was unpleasant news, but orders were imperative, and as far as one could see the banks were as bad or worse in other places; so, smoothing off the surface as far as possible and keeping

* Although all enquiries had been made we had been unable to ascertain the true nature of the river. The general impression gained was that the banks were high and precipitous; the velocity anything from six to ten miles an hour; the bed rocky and giving no hold for anchors; and moreover that the river was liable to sudden floods, which came down like a wall, carrying everything before them and sometimes rising twenty feet in the night. Fortunately for us this description proved generally incorrect, though it may be true in time of excessive rains.

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them off the rocks as much as we could, we slid the pontoons* down; they plunged into the river, nose first, and suffered no damage except that they got a small tear or two and took in a few gallons of water over their bows.

A small backwater under the lee of the island was chosen for the launching place. Further out in the river the current gradually increased until it ran at about four miles an hour. The first six pontoons launched were formed into a ferry, which was completed at 9 a.m. Each pontoon carried from 20 to 25 men and in this manner a regiment was ferried across in three-quarters of an hour. At 9.30 a.m. the West Yorks crossed and occupied Wright's farm, by this time deserted by the enemy; they were followed by the leading regiments of General Woodgate's brigade. In the meantime a "medium" bridge (No. 1) was being formed just below the island; the first portion was made along shore and swung into position, the remainder, in the strong part of the stream, being constructed by "forming up."† The total length of the bridge was 70 yards. It was completed by 11 a.m., when, a zigzag path having been made down the cliff, the remainder of General Woodgate's brigade began to cross. On the completion of the bridge, ferrying was stopped and the pontoons passed up stream, and the 17th Company, R.E., commenced a ramp a few yards down stream to allow of the passage of wagons. These

* Pontoons are made of a light wooden framework, with a thin sheeting of wood covered with waterproof canvas, and this of course is very easily torn by friction against rocks or stones.

† A pontoon bridge is usually constructed either by "forming up," *i.e.*, by taking out each pontoon in succession and connecting it with the portion of the bridge already built out; or by making the bridge complete alongshore and "swinging" it into position. A pontoon consists of two sections, a bow end (11′ 6″ long) and a stern end (9′ 6″ long), coupled together, but each of them capable of being used separately, and each having a bouyancy of about 7,000 lbs. To form a bridge, pontoons are placed lengthwise in the stream and are connected by baulks 15′ long. The distance between the centre lines of two adjoining pontoons is termed a "bay." "Chesses" are laid across these baulks and form the roadway, and they are "racked down" with "ribands." Bridges are of three descriptions, heavy, medium, or light. The heavy bridge is made with three sections of pontoons coupled together, and, as a rule, with nine baulks; it has a safe flotation of 18,000 lbs. The medium, which is the normal bridge, consists of two sections and five baulks, and can safely carry a load of 12,000 lbs. In both these cases the roadway is 9 ft. 3 in. wide. The infantry (or light) bridge is made with one pontoon section, the roadway being 4 ft. wide; it will carry infantry in file and led horses. In all bridges every alternate pontoon is held in position by up and down stream anchors. In "forming up," these anchors have to be placed by an anchor boat. In cases where the banks are steep, trestles have to be used in lieu of pontoons for the inshore bays, in order to form a ramp, which should not exceed a slope of 1 in 7. Trestles can also be used to bridge a dry ditch or shallow stream, where the depth of water is insufficient for the proper flotation of pontoons.

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ramps were completed by 2 p.m. when the bridge was dropped down stream and anchored in the new position. Some cavalry and the lighter military vehicles (field and machine guns, ammunition and water carts) then began to cross, the vehicles being passed down and up the ramps by hand and the teams walked over. There was only one accident; two mules fastened together fell into the water and were drowned. At 6.30 p.m. General Hildyard's brigade crossed, and after this the passage of artillery and carts recommenced and continued all night.

In the meantime the C.R.E. of the 5th Division organised a large infantry working party, and ramps were commenced to admit of a second bridge (No. 2) for heavy traffic near the upper end of the island (*Photo* II.). The ramp on the south side ran along the side of a donga, and by noon was sufficiently advanced to allow of a trestle bridge (at a slope of 1 in 7) being constructed from its end to the island below; this bridge was 20 yards long. From the end of the bridge the boulders were cleared away and a road made across the island. The north bank was separated from the island by 35 yards of water; but the full force of the stream was concentrated into this small space and the torrent rushed past like a mill race at the rate of about seven miles an hour, making the construction of a bridge a matter of some difficulty. The north bank too was a difficulty, rising perpendicularly to a height of 30 feet; but fortunately there was no rock and, beyond the labour of digging, no obstacle to the construction of the ramp, which had to be cut along the side of the cliff, making a difficult right-angled turn for wagons coming off or going on to the bridge. The construction of this bridge was rather slow, owing to the strength of the stream; the anchors had to be firmly planted behind rocks or secured to holdfasts driven in on either bank. The central boat was held by three cables, those on each side of it by two, and the remainder by one; and a trestle was put in at the shallow end. On account of the current, which tended to pull the bows of the pontoons under water, and also because of the large traffic the structure had to bear, a "heavy" bridge was put in. The ramp was completed at 7 p.m. and the bridge connected up with the northern bank; from that moment for twenty-six and a-half hours an uninterrupted stream of heavy traffic poured over the bridge.

It was with some anxiety that I watched the crossing of the first few lumbering ox wagons with their heavy loads, especially over the trestle portion* which had never before been subjected to the searching test of actual experience. The timbers creaked and groaned; but, to my relief, they were only taking their bearings, and in a few moments all doubt as to their standing were removed. The

* These were Weldon trestles, made hastily from our own design at Pietermaritzburg.

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wagons were all driven down the trestle ramp on the south side and then across the island; to go over the pontoon bridge the spans had to be taken out and the wagons passed over by hand, as the sharp turn off the bridge and up the far ramp was impossible for oxen. Generally speaking, on this and other occasions, we found that horses crossed without trouble under all conditions; oxen soon got accustomed to the work and passed without difficulty as long as the roadway was dry, but when wet and slippery it was almost impossible to get them to move; with mules matters were not so easy. However, even with mules, it was more often the native drivers than the mules that were afraid. The native, when he saw what was before him, hardened his heart, stretched out his legs to their full extent, tightened the reins, and, throwing his body back and putting his full strength into his efforts, shrieked loudly and discordantly at his team, to which by this time he had imparted his own fears. By making the driver drop his reins, put away his whip, and either remain perfectly quiet or dismount altogether, and by leading the two front mules or all of them if enough men could be found, the teams were generally got across fairly easily.

All artillery and light vehicles finished crossing the lower bridge (No. 1) soon after daylight on the 18th January, but the upper bridge (No. 2) was in constant use until 9.30 p.m. without an accident of any kind taking place. At 2 a.m. on the morning of the 19th one of Sir Charles Warren's staff officers arrived with instructions that a bridge might be required at Venters Spruit; so Lieut. Skipwith went back with him to headquarters and brought orders at 4 a.m. to break up the lower bridge and to send material forward for a trestle bridge 45 yards long. We at once dismantled the lower bridge (No. 1), and packed up the necessary trestles and superstructure, and at 7.45 a.m. Lieut. Skipwith started with two detachments* for Venters Spruit, three miles distant. At 2 p.m. a trestle bridge of seven bays (35 yards) was completed across the deep spruit, and ramps made by infantry working parties. Two companies of the Somerset Light Infantry arrived during the morning as a bridge guard, and immediately set to work to dig trenches and to take other precautions for defence.

We occupied Trichardt's Farm, which boasted tables and chairs, a bedstead or two, a good kitchen range and other luxuries, and for the next day or two lived a quiet and almost luxurious life. In another farm near by, denuded of all furniture except the family coffin,† there was an excellent supply of half ripe peaches, which, when stewed, formed a most welcome addition to our somewhat homely diet of "bully" beef and biscuit.

* The Pontoon Troop is told off into bridging detachments, each detachment consisting of one N.C.O. and seven men.

† It is the custom in the Dutch farmhouses to keep a coffin ready to meet contingencies.

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In the evening I rode over to headquarters at Venters Spruit to see our detachment there and to get orders. The encampment in the dusk was a very remarkable sight; the whole force was collected and closely packed together in a sort of punch bowl, with camp fires flickering all round; the centre of the punch bowl was cut in two by the narrow and deep spruit, now almost dry, but with evident traces that at times a roaring torrent rushes along its rocky bed; while a barrier of hills completely hid the force from the Boer position.

Next morning, the 20th, the only excitement was the passage across the bridge of the prisoners taken by Lord Dundonald's force at Acton Homes. We then made our first near acquaintance with "brother Boer," whose representatives we found to be unprepossessing in appearance, with ill-fitting dirty clothes, battered wideawake hats, and scowling and furtive-looking features. The remainder of the morning was passed quietly in the cool verandah of the farmhouse; and amid its quiet scenery, with the doves cooing pleasantly all round, it would have been difficult to believe that a battle in real earnest was going on a mile or two away, had it not been that the artillery and infantry could be seen in front taking up their positions on the hills and that the cooing of the doves was interrupted from time to time by the booming of guns and the crack of rifles.

Quite a large luncheon party unexpectedly turned up, our numbers being increased to ten by the addition of six officers, who were passing through with three companies of General Woodgate's brigade, and of a well-known war correspondent, who was fully prepared to do justice to our meagre fare. Our rations for three were eked out with porridge and stewed peaches; and our quarter bottle of whisky and half bottle of limejuice, judiciously mixed with large quantities of water, made everyone feel that they had had a good meal. The rub came in the evening when there was next to nothing for dinner.

We got cheering news of the fighting. Bastion Hill and two other positions had been taken, all was going well, and our casualties were not heavy. Convoys went backwards and forwards over the bridge, and everything was as we expected it to be. On January 21st, more convoys, just enough to keep us busy. At 5 p.m. the ambulances arrived with the wounded, which included eight officers, five of whom, only slightly hurt, came to tea with us; it was rather a blow to them, when they rejoined the ambulances, to find that the other wounded were having a much better meal of both tea and bovril. But after two days' rather scanty rations they were still hungry and, equal to the occasion, went for a second "spread."

Skipwith and his party rejoined in the afternoon, the bridge at Venters Spruit being no longer required. Our food supply was increased by a present of a fish from the officer in charge of our guard, an enthusiastic sportsman who spent his few leisure hours fishing in the Tugela. But we were never destined to taste this fish;

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it did not appear at dinner, and on enquiry we learnt that the cook "did not think it fit to eat" and threw it away.

The following morning, leaving Skipwith and his two detachments in charge of the bridge (No. 2), the remainder of the Troop marched at 6 a.m. to Potgieter's Drift. Immediately after leaving Trichardt's Farm we met General Talbot-Coke's brigade *en route* to reinforce Sir Charles Warren's force in front of Spion Kop.

Simultaneously with the advance on Trichardt's Drift, General Lyttelton's brigade moved on Potgieter's Drift, under Spearmans Hill and Mount Alice; and, crossing the drift with some difficulty, occupied the kopjes in front, facing the Boer trenches on Brakfontein. The drift was little more than 2½ to 3 feet deep, though one correspondent, who had a fall when crossing, described how he and his horse had to swim for their lives in eight feet of water; but the stream was running pretty strong, and had it not been for the help rendered by the 37th (Field) Company, R.E., with their pontoons some men might have been carried away.

After settling into camp at Potgieter's we made a "heavy" bridge (No. 3) near the drift, floated it down stream, and then swung it across, utilising the existing pont as a portion of the bridge and the ready-made cutting as an approach to it. The river was here 70 yards wide and ran at one and a-half miles an hour, having fallen and slightly decreased in velocity during the previous few days of dry weather.

On the morning of the 24th we started making a suspension bridge, thinking it might come in useful; but at 10 a.m. General Lyttelton gave me orders to make a bridge higher up the river to help the King's Royal Rifles in their attack on the two sugar-loaf hills on the eastern extremity of Spion Kop. Sending back orders to collect the oxen, and giving Lieut. Ommanney instructions to follow with the material, I reconnoitred the south bank of the river, along which there is a rough wagon track. Eventually I settled on a position for the bridge (No. 4) at the western bend of a large loop which the river makes towards Brakfontein. While waiting there for the arrival of the troops, the King's Royal Rifles and the Scottish Rifles passed on the way to a drift a little higher up the river. As the track was very rough we had great difficulty in getting our wagons up. Three of them turned over when crossing a small, but very steep and difficult, donga, and had to be unpacked and reloaded. At 2 p.m. we commenced to unpack the wagons; and having carried the pontoons down the high and steep bank, we formed an "infantry" bridge (No. 4) along the bank and then swung it across the river, 75 yards wide, into position. It was finished by 4 p.m. and we then had our dinner, for which we were quite ready, having breakfasted at 7 a.m. The ramps were afterwards dug, and completed by 8 p.m.

While the work was in progress we watched with intense interest

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the battle that was taking place on Spion Kop, not realising indeed that it was a life and death struggle, but still appreciating its severity. On the extreme left our troops toiled slowly up a long steep slope until they reached a point that was marked by a few small trees silhouetted against the sky line, where there appeared to be some slight confusion, and where from time to time men were seen to make rushes for cover. From there the crest line of the hill was lost to our sight, but the southern face, rocky and most precipitous, was in full view. The shells were bursting on this position, and the rapid movements of the men, who were there seeking what was apparently but indifferent shelter, gave some idea of the fury of the fire on the small plateau above. Shell after shell came pouring mercilessly from two or three directions, searching out, like fiends incarnate, every nook and cranny that afforded the least protection, and one's heart bled for the poor fellows who were so nobly laying down their lives for their Queen and country on that bare hilltop. About 6 p.m. the intensity of the fire increased tenfold, and the position held by our troops was absolutely ablaze with bursting shells, the flames from which showed up plainly now that the sun had set and twilight was beginning.

Further to the east we saw the gallant King's Royal Rifles cross the plain intervening between the river and Spion Kop and commence the steep ascent of the conical hills on the left of the Boer position. Slowly they began, in widely extended order, what would at any time be a difficult climb up the steep sides and over the occasional outcrops of precipitous rocks, but what now, in the great and parching heat, and fully equipped as they were with rifle and ammunition, must have been an enormous effort. In spite of all difficulties they carried on and were at last lost to our sight near the top; and from the musketry fire we could tell that they had found and engaged the enemy. Darkness soon hid the battlefield from our view, but before long the more slightly wounded began to arrive at the bridge head, where a blazing beacon was lit as a guide. At first we heard that everything was going well; then that the casualties had been heavy, that Colonel Buchannan Riddell of the K.R.R. had been killed at the top of the hill, and that other officers and a goodly proportion of the men had been killed and wounded; and finally that a retreat had been ordered, and that the hill was to be evacuated.

The ambulances arrived at the south bank of the river and the wounded were attended to as quickly as they came in, and all through the night a stream of men returning from the front crossed the bridge. Orders were sent during the night to remove the bridge (No. 4) as soon as it was considered that all stragglers had come in. The dismantling was commenced at 7 a.m. and, when completed, a light Berthon boat was left with a small party to help anyone who might have missed his way during the night.

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At 6 a.m. on the 25th orders were brought to break up both this bridge (No. 4) and the one at Potgieter's Drift (No. 3) and to return to Trichardt's Farm as soon as possible. Leaving Lieut. Ommanney with the light bridge, I collected a working party of 200 men of the 4th Brigade, and at 10 a.m. started dismantling the heavy bridge at Potgieter's. This was completed and the pontoons packed on the wagons by 12.30 p.m. Lieut. Ommanney and his men having meantime rejoined me, the camp was struck and packed, and the loaded wagons sent up to await the arrival of the remainder of the troops on Spearman's Hill.

The road up Spearman's Hill was quite the steepest and worst we meet with during the advance through Natal; it was strewn with loose boulders and furrowed by streams of water that poured down it during rains. All attempts to mend it were hopeless; the surface could not be got to bind, and wagons coming down with their hind wheels held fast by the powerful brakes tore deep ruts. All wagons going up had to be double-spanned; so with our long convoy it was a tedious business, and took us over two hours to get to the top. We then pushed on to Trichardt's Farm, arriving at 5 p.m., glad enough to get in and to have our dinners, as we had had no food since breakfast at 6 a.m.

A site for a second bridge was selected a little way up the stream and round the bend of the river, where it would be covered from the Boer guns on Spion Kop. The drawback to the site was the bank, as there was a strong outcrop of rock with a drop of from six to eight feet. The C.R.E. of the 2nd Division undertook to have a ramp made and also a roadway for wagons to the river bank, and at 9.30 p.m. we again paraded for work. The night was as dark as it was possible to be, and although we lit a small fire to help us we found it absolutely impossible to launch the pontoons. In the dark one could not see what one was doing, and the perpendicular ledges of rock made the carrying of the heavy pontoons down the bank both difficult and dangerous. The men too were dead tired. So at midnight, finding that little progress had been made, the completion of the bridge was deferred until dawn. Ommanney and the sergeants went on working until 1.30 a.m., and got all the wagons taken along the river side until it was possible to turn them, and brought them back to the tail end of the main bridge (No. 2) at Trichardt's Farm.

At 4.30 a.m. next day (26th) we set to work again. The pontoons were brought down the ramp bridge on to the island, and there unpacked, launched, and formed into rafts, which were rowed up in the slack portion of the stream and formed into a "medium" bridge (No. 5). The bridge was completed by 6.40 a.m. and the ramps were afterwards made by the 17th Company, R.E.

During the day a constant stream of artillery and ammunition wagons and baggage passed over the heavy bridge (No. 2) and the

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drift below was also in constant use. All our spare equipment was sent to Spearman's Hill and the place cleared as much as possible. At 6 p.m. all the necessary pontoon wagons, etc., were parked ready on the island and at the tail of the trestle ramp on the south bank of the river. As soon as it was dark the retirement of the force in front of Spion Kop began. A large bonfire was made on the island to guide the returning troops, as the night was very dark and there was a thin drizzling rain. Until 2.30 a.m. there was a continuous passage of artillery and other wheeled traffic over the bridge (No. 2); yet with the exception of one accident (an ammunition cart with its two mules fell over the embankment on the north side and into the river below) everything was got safely across, although at times there was a good deal of trouble with the mules in the ambulance wagons. From 2.30 a.m. there was a lull in the proceedings for half an hour, and then the infantry of the 5th Division began to cross and went on without intermission until 6.30 a.m.

Meanwhile all the cavalry and the infantry of the 2nd Division were crossing the medium pontoon bridge (No. 5) thrown across that morning. The passage commenced at 8 p.m. and continued without intermission and without accident until 5.30 a.m. next day. At 6 a.m. this bridge was broken up into rafts, floated down stream, and packed on the wagons, the Troop being assisted by fifty men of the 17th Company. Each wagon was sent away when loaded, and the island cleared as quickly as possible.

On the appearance of daylight it was found that one of the mules belonging to the overturned ammunition cart was alive; one of our drivers went into the water and cut it loose, and it got safely to land, little the worse for the accident; he also cut the drowned mule loose and let it float down stream.

At 6.30 a.m., on the completion of the crossing of the 5th Division, the dismantling of the heavy bridge was commenced; its superstructure had been much worn by the heavy traffic over it all night.

Before the dismantling was completed a message came down that we were to try and save the ammunition. This was not so easy as the wagon was overturned and was bottom upwards in three feet of water in the swiftest part of the stream, and, in addition, the brake was screwed up tight and could not be reached under water. But after working at it for three-quarters of an hour, we got it out without damage and fastened it to the rear of our wagons. We were again interrupted in our work; for just as we were going to get out the last pontoon, four stragglers appeared on the opposite bank, where they were shortly joined by two more; so we had to send across to fetch them. When the pontoon bridge was all packed up and sent away, the trestle bridge was dismantled. As the last lashings were being made fast on the last wagon (at 8.35 a.m.) the Boers seemed to see us for the first time, and opened fire with a big gun which had been

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brought up on 'Ntabamnyama during the night. They only fired one shot before we got away, but it was excellently placed, the shell skimming just over our heads and falling into the donga behind. Just before this happened an A.D.C. came to say that another straggler was on the opposite bank. Taking a coil of rope Lieut. Skipwith went down to the river and, wading in as far as he could, threw the rope across to the straggler, who fastened it round his body, and was then hauled through the strong current and got to shore half drowned.

The whole force bivouacked about a couple of miles in rear, where they were behind a nek and under shelter from artillery fire. During the morning orders were sent to ferry a burial party across the river to Spion Kop; two pontoons were told off and left camp at midday, looking very proud of themselves after their recent hard work, going as if to an inspection parade with their detachments sitting inside them and large new red cross flags floating from their bows.

In the afternoon the 5th Division retired on Springfield and the 2nd Division took up positions overlooking the river. Thus ended the first crossing of the Tugela.

(*To be continued*).

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SOME MILITARY ASPECTS OF AUTOMOBILISM.

By CAPT. R. S. WALKER, R.E.

I HAVE been induced to prepare the following notes on the military aspects of automobilism, as they have from time to time occurred to me, by the thought that my experience with automobiles has been unique, and that I look at it from quite a different standpoint to that of those who have been brought up with the movement at home.

My first experience was in South Africa, under most adverse conditions, when we expected and got out of various cars of second rate manufacture more than they were ever dreamed to be capable of; naturally, we had many breakdowns, so we picked up our experience in the best possible way. After the war, as I was known to take an interest in automobiles, I had the privilege of pulling to pieces nearly every make of car that found its way into the country, large numbers of them from America and Germany. This experience, added to that gained in driving over the bad South African roads through drifts and across country, made the roads seem quite strange when I came home and started Continental tours.

On these trips also my experience has been somewhat unique, about 15,000 miles in 6 months, a large portion of the time alone. I did not stick to the main roads, but visited out-of-the-way places in France, Switzerland, Italy, Austria and Germany; burst a tyre from the heat in Italy; nearly got snowed up in the Tyrol; followed the whole of the Italian manœuvres; and tackled the mountain tracks of Bohemia.

I have driven very little in England up to date, and found the conditions quite strange to me. I therefore think my motor experience has been more akin to military requirements than that of most owners of cars; and I give my opinions, for what they are worth, in the hopes that others may find time to elucidate the many, as yet, undetermined points, and be saved from disappointment should they subsequently come across the difficulties to which I call attention.

I must tender my thanks to Messrs. Ludwig Löhner and Lindemann, and to Capt. R. K. Bagnall-Wild, R.E., to whom I am indebted for much of the material for preparing this article.

Part I. suggests a use for automobile engines; II. to V. deal with the details of various types of machinery; VI. and VII. with special types; VIII. with the military requirements of an automobile and a description of a car designed to meet these requirements during the war; IX. with unsolved problems.

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I. A USE FOR AUTOMOBILE ENGINES.

The development of automobilism has incidentally put into military hands a very useful article, viz., an engine of large power for its weight and of comparatively simple construction.

When one considers the numerous things which have to be done by manual labour during and after a day's march, which could far better be done mechanically, thus saving the men from unnecessary fatigue, one realizes what a benefit the automobile industry has been to the army.

Any of the forms of power used to propel automobiles could be carried in the field by R.E. Field Troops and Companies, the weight of the motor, etc., being counterbalanced by the diminished pump equipment.

Taking as a basis a 3-B.H.P. unit, the weight of an outfit complete with accessories could be reduced to about 2 cwt. for petrol, 3½ for steam, 5 for petrol electric, and 6½ for steam electric. Assuming an all-round efficiency of 50%, such a motor would supply over 150 gallons of water per minute at a height of 10 ft. or *all* the wants of a Division for a day in 10 hours. A centrifugal pump with flexible coupling would probably be found the handiest to use; this and a petrol motor would weigh no more than a service lift-and-force pump.

The motor could be used for numerous other purposes, *e.g.*:—

with a circular saw, for felling trees, cutting up firewood, etc.;
with a small lathe, drill, emery wheels, etc., for wagon and automobile repairs (as Q.F. guns and automobiles come into use, the field workshop will have to become more elaborate; this is compensated for by the saving in forage, farrier and veterinary equipment);
with a blower, for several forges;
with a small pulley, to act as a winch, for helping wagons, etc., out of bad places; with derricks, for lifting weights, to pull boats, etc., across rivers, to pull carriers across suspension cables, to haul down balloons, and in numerous other ways. (This winding drum in the case of a petrol or electric motor would be a pulley about 3 or 4 inches in diameter).
with a drilling machine, for boring holes for blasting; possibly also to save the manual work of the jumper men in telegraph air-line work.
with a dynamo, for supplying electric power.

It sounds at first a very roundabout way of doing things to suggest that the engine should be coupled to a dynamo, and that the pump

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saw, etc., should in turn be driven by an electric motor. But a point well worth considering is that electric transmission is so flexible ; the motor will run in any position providing lubricating arrangements are properly designed, and it is hard to conceive making a coupled steam or petrol engine equally flexible. Then we have the advantage that our electric motor can be run faster, and so be lighter and more portable, and the power plant can be a fixture on its own cart. Lastly, an electric outfit can be used for other purposes, for which a prime mover cannot, viz. :

with incandescent lamps, to load trains and wagons, to repair roads, railways, etc., to illuminate ground in case of a night attack.

to replace dynamo exploders, being capable of firing through much worse circuits (the dynamo for a 3-H.P. set would not weigh much more than a service exploder).

with search lights, the use of which will I think be found essential to reap the benefits of a successful battle, a result now-a-days usually impossible because of darkness. (A 3-H.P. outfit is sufficient to run a 1 ft. projector, which, although not powerful enough to be of much use in English fogs, is certainly enough for a clear atmosphere, such as exists in many countries we may be called upon to fight in).

If a heavier search light equipment be adopted, its engines might be used in the daytime for pumping, etc. A 2 ft. projector would require a plant weighing about 10 cwt., a 3 ft. one of 20 cwt.

It is doubtful if a petrol motor is the best type. When in order it can be started at once, and requires little fuel, attention, and water. The only drawbacks are that it will not stand an overload without pulling up ; and that it is not at present as well understood as the steam engine, and gives frequent trouble and will continue to do so until it is understood. Even if we duplicated our motors they would probably both jib at the same time for the same reason ; so that it would seem best for the present to pin our faith in steam, which every engineer understands ; it gives warning before it breaks down, and if it is working at knocking-off time to-day may be counted on to work first thing to-morrow, which cannot be said of the petrol engine when taken away from the congenial climate of Europe.

Eventually, however, the petrol engine may oust steam because of its simplicity and the greater economy in fuel.

The power unit, in whatever form, could easily be fixed on any cart or wagon, as was done in many cases with steam electric and petrol electric outfits in South Africa. By specially designing the equipment the difficulties of pack transport even of a boiler could be got over, though the petrol engine is undoubtedly the readiest to

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adapt to this form of transport. A 3-H.P. petrol electric outfit could be loaded as under :—

1st mule. Engine, fan, petrol tank, carburetter, tools, etc.; base to fix engine and dynamo to for running.
2nd „ Dynamo and instruments.
3rd „ Cable.
4th „ Electric motor centrifugal pump and hose.
5th „ Projector, tripod, incandescent lighting gear, tools, etc.
6th „ Saw, drills, emery wheels, spare parts, hose, etc.
7th „ Water;

in addition one mule for petrol per 50 hours the engine is likely to be used.

Other uses will occur where mechanical power could be used in the field, to the saving of men, who can ill be spared from outposts and other military duties. All officers of Engineers know how grudgingly the necessary fatigue parties for pumping, etc., are granted; and it would seem that the adoption of some such equipment is justified, especially as it will not increase the loads we have to carry nor the necessary trade qualifications of the men.

II. REMARKS ON STEAM MOTORS.

In considering the various forms of motive power, I will assume an acquaintance with the forms in general use and confine myself to calling attention to points which forced their attention upon me in various ways.

Steam is the form of power best known, and as such was naturally the first adopted for automobiles. In the heavier classes it may be said to thoroughly hold its own, but in the light class its use is most uncommon; this is chiefly the outcome of the mechanical ignorance of owners of cars, and their absence of concern for their motor, which would be fatal in the case of steam cars. But whether the petrol engine is sufficiently perfect to justify its lead is a moot point. It is a remarkable fact that in America, where roads are bad and the load a rapidly varying one, the steam car is more frequently used. With a steam car, if you stick on a hill you can get up a good head of steam and do another sprint, and so on till you get to the top; in sailing down hills you can fill up with water and regain normal conditions; this is a great advantage in bad country, and means that the boiler only needs to be sufficient to steam continuously at about half the power of maximum load. A steam engine can be double-acting, and economically regulated; the parts can be inspected whilst running, and incipient faults can generally be detected in this way; these faults are easy to diagnose, and the remedies are mostly simple and easy to carry out. A steam car may be said to have an infinite number of "speeds." For military purposes a steam car has great

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advantages in its silence (several times cars passed within 100 yards of blockhouses on a still night without being heard).

On the other hand, if good water is not to be had, great care is necessary; the engine, boiler and furnace want continual attention, which is much more than that for petrol engines; it takes about ten minutes to get up steam, and if petrol or paraffin is used for fuel you will consume about twice the quantity required for a petrol car to do the same work.

Boilers of flash or semi-flash type, although they do not scorch, all seem unsatisfactory, and are very complicated and difficult to repair; the latter remarks also apply to water tube boilers. Undoubtedly the simplest boiler is the cylindrical with vertical fire tubes, a type which everyone will scorch to begin with; but once a man is used to it, he can keep his water at the proper level, even without a gauge glass; such a boiler can generally be repaired in the field.

The Klinger gauge glass is the only satisfactory one. Superheaters, although simple in themselves, cause trouble with lubrication; this may be got over to a certain extent by using plenty of graphite with the cylinder oil. Leaky glands also seem to be more common with superheated steam; on the whole it seems an unnecessary complication, which is not justified by practice.

For military purposes a paraffin furnace would be a great boon (paraffin being so much easier to store and safer to handle); unfortunately it has a nasty habit of decomposing in the parts of a burner and eventually choking the tubes, etc., it passes through. The only paraffin burners we had, which worked satisfactorily, were of the steam paraffin jet types; a very good burner was such an one from an American launch by Shipman, but the boiler was heavy, and it is hard to see how the principle could be adapted to the cylindrical fire tube boiler.

The petrol furnace used in America, with small petrol holes, round central air holes, corresponding to the boiler tubes, is the best up to date; but it is a demon in high winds; the only way to cure blowing back seems to be a live steam jet in the chimney.

In some of the small engines ball bearings have been introduced. For military work, this is not an advantage; repairs may have to be executed in the field, and looking for a ball in a dusty road is like looking for the proverbial needle.

Although they have not yet been used in automobiles, steam turbines of the de Laval type are worthy of military consideration. These little motors, running at 30,000 revs., weigh little; unfortunately the speed is too high, and the reducing gear does weigh something. They require absolutely no attention beyond filling their oil tank periodically, and they govern perfectly. We had one running nightly for 14 months with steam at all sorts of pressures, and often very wet, and it was as good as new at the end. The remarks about

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saturated steam above do not apply; and when used with a condenser, no separator is required as no oil enters the steam chamber.

In considering a steam electric outfit these simple machines are not to be lightly put aside. As at present made a steam dynamo of 3 H.P. would weigh more than mentioned in I. above; but there is a great deal of cast iron in the base, covers, etc., etc., which could equally well be of aluminium or thin steel, so that the weight could be very considerably reduced. A 3-H.P. set weighs now, I think, from 2 to 3 cwt., and could be reduced to from 1 to 1½ cwt.

Condensers are a military necessity to increase the radius of action; probably the beehive and fan would answer all requirements.

Automatic devices should be avoided. They only serve to give a false idea of security, invariably get out of order, and require a great deal of work before they can be put right again or got rid of (which is sure to be their ultimate fate). I do not include safety valves in the above remarks, though even they may prove a delusion; I remember one night, with a Search Light plant, finding the pressure gauge hand hard against the zero stop on the wrong side; I started the engine very hurriedly; next day I discovered that a genius, who had had the safety valve off to clear the tube, had plugged it up with cotton waste! The pop safety valve might be a serious nuisance; it has a nasty knack of going off like a fog horn, which, besides frightening horses, would give the show away on a night reconnaissance (just the job for a steam car) when one would be likely to keep a full head of steam ready to dash away with.

III. EXPLOSION MOTORS.

The Otto cycle may be said to have been adopted in all successful explosive motors of modern design with one exception, and that exception is not yet on the market.

The theory of explosive motors has not received nearly so much attention as that of steam, and consequently we are continually brought face to face with problems which no one seems able to solve. Ask any mechanist what he thinks of an explosive engine, and he will say they are all right when they run, but they're devils once they begin jibbing. He will probably not admit that he does not understand them as well as steam, but this is the case; and so long as it is so, the explosive engine will never be given a fair chance; it is damned by its driver before he tries it!

At first sight, by the side of steam, the petrol engine is simple, but when we analyse matters we see that this very simplicity is a sign of its crudeness. Were efficiency of no importance we could design an equally simple steam engine. An explosive engine is noisy, which is bad from a military point of view.

The weight of an explosive engine, as against that of a double-acting steam engine, is much greater, there being only one working stroke

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in four; for equal mean pressures and speeds the cylinder would be about 4 times as heavy. On the other hand, the weight of fuel used, allowing for the present worse efficiency, is about $\frac{1}{4}$ that of coal; no boiler is necessary; the small quantity of water required for cooling is also a great advantage, and with pure fan cooling none would be required. An explosive engine requires practically no attention when running.

If we could use petroleum as our fuel, as already stated in II., it would be a great advantage. At present there are two ways of turning the liquid used into gas; firstly, by squirting it into the hot cylinder; secondly, by vaporising it outside and admitting it through a valve. The vaporising, in the case of petrol motors, is combined with the admixture with air in the carburettor. No paraffin vaporiser is at present reliable enough for automobile use.

There are many types of carburettor; and the present tendency is to simplify them and do away with all adjustment, *i.e.*, no matter what the state of the air to have the same sized air and petrol openings. This is very nice for those who wish to turn the handle, start their car, and never bother any more about it; but will not do for military purposes, where we want always to get the most out of our engine, provided it does not get over complicated. With different air and different petrol we have different proportions in which they should be mixed to get the best results; if anyone does not believe this, he should drive a car with a Longuemarre carburettor from just before to just after sunset in a hot country, and try the effect of varying his mixture. There should be levers for hot and cold air, petrol, throttle, and ignition. In some carburettors air is admitted after the mixture has been formed; this may re-condense the petrol, and the place of admission must be carefully chosen.

In the cylinder good material is essential, as there is a great tendency to wear from the obliquity of the connecting rod, which does not occur in steam engines. When once a cylinder has worn oval, new rings will soon fail to make a tight joint; and the result will be considerable loss of power, firstly due to loss of suction, secondly to loss of compression and consequently of explosive force, and lastly to leakage of the explosive mixture past the pistons.

The efficient cooling of cylinders is a great point, and I venture to state that no petrol car has sufficient cooling arrangements for a hot country. Owing to bad roads, I have frequently been unable to travel faster than the wind, and most of the time with the engines working at full load; this on a hot day travelling down wind is the equivalent of running the motor at full load in a boiler house. How many cars would stand that for long? Once, to avoid this, I left Pretoria for Johannesburg after dark; and although the whole distance is only 40 miles and we completely changed the cooling water once, we had to stop two other times for about $\frac{3}{4}$ hour each time to cool down;

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the last 10 miles was at right angles to the wind and on fair roads, so that we travelled faster. Fan cooling is therefore essential.

Dry batteries in a hot country are no good for ignition purposes, they soon get dry !

Accumulators, unless you carry your own dynamos, are difficult to charge ; and owing to the rough roads they splash, get dust in them, and rapidly deteriorate.

Sparking coils must be kept well away from hot parts and the sun ; otherwise the paraffin may melt and put them out of action.

Magnetos, when standing in the open, may get damp and be difficult to start.

Other ignition troubles, which may be ranked next to tyre troubles, are known to all automobilists ; and I am of opinion that, for a military car, there should always be a second form of ignition.

IV. ELECTRIC POWER TRANSMISSIONS.

The chief advantages in the military application of electricity to the propulsion of automobiles seem to be :—its simplicity, the reliability of all electrical gear, the silence with which it works, and its flexibility. Under the latter heading it is worth noticing the following :—suppose two automobiles are together, and the source of power in one fails, the other can supply it with power ; and if the other's motors break down, it can couple itself to the first, and supplying the power, be towed by it. Its flexibility also shows itself in the fact that, like steam, an electric automobile may be given large numbers of "speeds." The source of power can be used for all the purposes enumerated in I., for which purposes other forms of transmission do not so readily lend themselves ; and thus an automobile tool cart would not need to carry the extra power outfit suggested in I.

The disadvantages are :—faults as a rule do not give warning ; and when used near paraffin or petrol there is a slightly increased danger of fire from sparks.

The source of power may be a dynamo, a battery, or a combination of both. As regards the dynamos, they may be direct coupled to a petrol motor, or driven by a chain or gearing.

Accumulators are very heavy for their power, and require a charging plant always near at hand ; for these reasons they are not suitable for military purposes. There is, however, a way in which they can be used, which has a great fascination, viz., as a supplement to the primary plant, so as to take the peaks of the load diagram, *i.e.*, help the engine take the car up a bad hill and be re-charged on the down grade ; in this way the engine might always be working at full load and maximum efficiency, and be of smaller power, and in the case of a breakdown the battery might save the situation. Unfortunately, the extra weight, as accumulators now go, more than makes

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up for the saving in engine power, and the gain in efficiency is swamped by the extra power required to carry the battery. If the weights of accumulators are ever reduced, the question will be worth re-considering, but the other disadvantages of accumulators would then also have to be taken into account; they need ventilating, and dust gets in at the ventilation holes; shaking damages the plates and splashes the liquid; and there is a great tendency to over-discharge.

Electro motors have one great advantage over petrol and even steam engines, in that, for the same power, the slower they run the more force they exert at the wheels.

In one or two types of electric cars, we find a front wheel drive, to which electric transmission is easier adapted, and a few remarks on this are not out of place.

Firstly, the whole car is pulled instead of being pushed, and so the frame can be built a bit lighter; secondly, there is much less chance of side slip (not altogether unknown with iron tyres); thirdly, it is easier to steer the front wheel clear of obstacles on the road. The only objection is that the front wheels are the steering ones, and do not move parallel to each other; so that, if the motor is not a part of the wheel, it must either be directly geared to it, and moved with it, or the drive must be through cardans.

If we adopt a military front drive, we can then either have a single motor and differential shaft, driving the wheels through gearing and cardans, or two motors either driving similarly or each gearing into the wheel and turned with it; the latter would seem to be the simplest.

Whilst on this subject it may be remarked that there are many occasions, in bad country, especially in mud, where one set of wheels will not grip but fly round, when the others which cannot be driven would grip; and it is worth considering whether, in a military car, we should not have all four wheels drivers, thus utilising the whole weight of the car for adhesion; the extra weight consequent on splitting up our power might be justified in practice.

V. MISCELLANEOUS MECHANICAL NOTES.

Besides the systems already enumerated, in America two other systems have been experimented with, it is said with success; and although for military purposes, for the reasons already stated, I advocate a steam or electric system, these systems with a petrol engine may be found to be more efficient than the usual form of transmission. The systems are hydraulic and pneumatic transmission.

Briefly the engine works a compressor; there is a reservoir, which has the advantage of a battery of accumulators (hence the economy); and the power is reconverted in water or air motors at the wheels. In the case of air this transmission weighs virtually nothing (tanks for

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storage and connections) besides the compressor and motors, which altogether should not be more than the weight of change-speed gears, chains, differentials, etc., let alone the reduced size of the prime motor. It would be very quiet also, and the exhaust air could be used to prevent the dust rising.

As regards the various forms of mechanical transmission most points are now understood. Belts for military purposes are out of the question because of their liability to get wet. Chains stretch, and provision must be made for shortening them and altering the length of drive. There is a very good American chain which can be opened anywhere, and a link taken out or put in ; this is also useful in case a link breaks (care must, however, be taken or the whole chain will tumble to pieces, a nice contingency on the roadside at night!) ; many spare parts and a complete spare chain should be carried. If a chain gets out of pitch it should be discarded at once.

It is worth noting that with a chain drive two or three different-sized driving pinions may be carried ; and the gear can thus be easily altered in a very short time according to the nature of the country and the work to be done.

Toothed, bevel, and worm gears by good makers may all be relied on, and with raw hide are fairly quiet.

The form of change-speed gear usually employed is objectionable from a military point of view for the following reasons :—unless you have a very careful driver, and Tommy is seldom that, they will wear badly ; they are also apt to become very noisy, and a bad driver changing speeds makes a great deal of noise.

There is a thoroughly mechanical gear, the crypto, used on many American cars, which has none of these disadvantages.

In considering gear there is another question, and that is the number of speeds required. In rough country with hills, etc., changing speeds is a great nuisance, and a two-speed gear is far easier to drive than a three or four-speed one. I am of opinion that the saving of the driver more than makes up for the loss of time and petrol. As an example, on a three-speed car, going towards Johannesburg from Pretoria, I counted the number of times I changed speeds, and had exceeded 100 and given up counting long before getting half-way ; the whole journey on a two-speed car only necessitated 10 changes of speed ; the relative differences in time are difficult to compute.

The above remarks on change speed gears of course only apply to petrol cars simple.

Cardan transmissions, although very simple and reliable, are not needed for military cars, unless to allow the frame to rack with a counter shaft drive.

Pipes for steam, air, water and petrol, and their valves, require to be looked at periodically, and blown through to clear out sediment or

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other obstruction; they must also have numerous bends to make them flexible. It is advisable to paint the different systems in different colours to facilitate tracing them.

Electric conductors must be well insulated; kept away from hot parts and the sun; never allowed to rub against or be rubbed by anything. All joints should be thoroughly insulated, and connections easily accessible for testing and cleaning purposes.

All bolts and nuts require frequent attention. All bolts should have lock nuts as well as split pins.

Parts of the car should be such that in case of damage they can be repaired even with inferior material. For example, in South Africa, a certain car had springs by Lemoine, undoubtedly the best spring maker; these springs were gripped in a sleeve which was only just large enough to take the same section spring, and could not be made larger; the front springs were broken going over a drift, and every smith of note was set to work to try and make a pair of springs; we succeeded with one, but a second which would hold, even driving carefully, could not be made, and the car had to wait till springs could be obtained from France. Many similar accidents might occur; and although there might be duplicate parts at the base or an advanced depôt, it would be much better to be able to make shift with something to be obtained locally rather than to have to wait.

It is needless to say that all threads should be Whitworth, Gas or B.A.; and that the number of sizes of bolts, and in fact of all parts, should be reduced to a minimum; in the Pretoria design we succeeded in reducing the bolts to two sizes.

All parts of engine, etc., should be easily accessible, and capable of being removed or replaced without needing a pit.

To ease the shock on engines, chains, and gears on starting, where an electro motor is not in use, it will probably be necessary to introduce a spring drive of some sort.

Brake blocks expanding inside a drum fixed to the wheels are the best form. Band brakes are nearly always on, and brakes on the engine, etc., are bad as they strain all the transmission gears unnecessarily. A tyre brake could be used on metal wheels.

Lubrication should as far as possible be regulated by sight feed lubricators, a separate way to each part.

Clutches should be water tight for passing through rivers.

Every tool and spare (in reason) which can be required should have its allotted place in the car, and those most often required should be very easily got at.

As regards tyres, first and foremost rubber will not stand hot climates and moisture is a great enemy to it. In South Africa pneumatic tubes and covers, even when not in use, got very quickly porous from these causes, and tyres cannot be counted on to last more than two or three months for tubes, and six months for

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covers. Solid tyres, which also have other drawbacks, would perish similarly.

Next come punctures, which will be more liable to occur on service than in peace, for two reasons,—(1) the roads will be upset, there will be many shoe nails, etc., on them, and (2) you will have to go up many country lanes and cross country; any cyclist who has followed large foreign manœuvres will support this. Punctures always mean loss of time. Suppose you puncture when near the enemy (if pneumatic tyres are used they will stretch barbed wire, strew nails, etc., on purpose), and jack up the wheel; you may get caught in the act, and then it is no good being able to travel 50 miles an hour. On the other hand, if you run on your rims, you may have to do so for miles and will ruin the tyres; you will have to drive slowly for fear of side slip (I had the pleasure of turning upside down in South Africa from this cause), and possibly smash a wheel or spring, and you may even get caught then.

Single tubes are not quite so bad as double ones; but when they puncture, they take ages to repair; and you probably pull the tyre to pieces if you run far on it deflated.

Pneumatic tyres for large wheels would also be very expensive, and very difficult to repair. Imagine levering on a 5 ft. cover!

The great advantage of pneumatic tyres comes in for very high speeds, but a military car will not as a rule be called upon for them. If such a contingency is contemplated, a set of pneumatic wheels of small diameter could be carried, and changed when such high speed is required; or ordinary cars could be kept for the purpose.

VI. THE LÖHNER-PORSCHE SYSTEM.

This is a petrol electric car, and consists of an ordinary petrol motor with pump, fan, and cooling arrangements. In place of the flywheel is a dynamo, the armature of which revolves, the field magnets sliding on a shaft in a position similar to a clutch of an ordinary car. The commutator is vertical and outside. The brushes are of carbon and very accessible. By this means the effects of vibration are minimized. The whole is covered from below to keep out dust and mud. There is a special governing arrangement, which consists of a spring equal in strength to the torque at full load. As the work increases the current supplied to the motors increases, the torque increases and the field magnets are slightly displaced; this increases the air gap and thus decreases the volts, with the result that (within limits) the dynamo runs at constant watts. By this means the engine is always running at full speed and full load unless you wish to throttle it, and an infinite number of speeds is obtained. For hills of a steeper grade than 7% a low gear can be obtained by changing the motors from series to parallel. Under the footboard is the

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commutator, which is worked by a lever from the outside. Whenever this lever is moved or the brakes put on, the current is shut off. The various movements correspond to going backwards, starting the engine with the accumulators or charging the accumulators, high speed forward, low speed forward, five degrees of electric brake and finally the back wheel brake.

The motors are fixed to the rims of the wheels by metal spokes, the field magnets being inside and fixed to the axle-tree arm. The commutator is also vertical. The whole runs on ball bearings and is contained in a dustproof cover. Most parts of dynamo and armature are interchangeable. The steering pivot is inside the field magnets and aligned with the wheel contact on the ground, the wheels being vertical. This obviates any chance of twisting the car round should one motor give out.

The steering is the ordinary irreversible type. The brakes are on the back wheels, and electric ones on the front wheels; the latter form practically obviates all chance of skidding.

Any form of body can be fitted to the chassis, since there are no chain wheels or differentials in the back portion of the car to hamper its construction.

The combined efficiency of dynamo and motor is 75% to 80%. The ordinary running pressure is 50 to 150 volts, and the current 116 to 232 ampères. Four cells are sufficient to start with high tension ignition, and seven with magneto. The weight of each front wheel complete with motor is $2\frac{1}{2}$ cwts.

The chief advantages seem to be;—any shape body can be used; a greater efficiency at full load; a greater mean speed unless purposely throttling; always working at full load; easy to start the car; easy to start engine; the engine not strained at starting or on irregular ground; the strain on the driver owing to change speeds entirely removed; the gearing most reliable; the chances of side slip materially reduced; the steering very easy, and the front wheels vertical at the same time; the wear and tear of gears done away with; slightly reduced weight; and less liability for the wheels to slip round on greasy or sandy surfaces.

On the other hand the driver requires more knowledge; and there is a slightly increased chance of fire.

Power Required.—The mean loss in the dynamo connections and motor is about 25%, as against 50% with gear transmissions in an ordinary car. With gears of, say, 40, 25, 15 and 8 miles per hour, and an engine speed of 1,000 revs., the mean speed of the engine of a petrol car on a road, assuming throttling is unnecessary, would be about 800 revs., so that the average unused power of the engine is about 20%. In the L.P. System you are always working at full load. Thus, for the same mean speed of gear, in the case of the L.P. system you need an engine of about $\frac{1000}{750} = 1{\cdot}3$ times the mean power required

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at the wheels, and in the case of an ordinary gear about $\frac{100}{80} \times \frac{100}{50} = 2{\cdot}5$ times the mean power, or about double the former, assuming everything else to be equal. In practice, however, the efficiency of the smaller engine is not so great, and the theoretical advantage seems to be reduced in other ways, so that it requires an engine of about $\frac{3}{4}$ the power to get the same effects with the petrol-electric system.

The petrol consumption is probably much the same in both cases.

As regards weight, that of the L.P. engine will be about 25% less. The armature of the dynamo acts the part of flywheel, and is about the same weight as a flywheel of an ordinary engine the same size. The field magnets correspond to the clutch, but are a little heavier. The motors and connections are but slightly, if any, heavier than the change-speed gears, cardan or chains and differentials, so that on the whole a saving in weight is obtained. All this weight is on the driving wheels.

Engine without Flywheel.		Dynamo.	Motors and Wheels.	Total Weight.	Engine with Flywheel.		Gears.	Total Weight.
H.P.	cwts.	cwts	cwts.	cwts.	H.P.	cwts	cwts.	cwts.
15	3	2	5	10	24	6	3	9
30	8	3	5	16	48	15	7	22
70	20	5	5	40	100	40	20	60

VII. THE HART TWO-CYCLE MOTOR.

This motor is of much the same construction as a four-cycle one, except that the valves are merely openings in the cylinder. There are five valves; one for the admission of the mixture to the crank chamber, one for the admission of the mixture from the crank chamber to the cylinder, one for the admission of pure air to the connection between the crank chamber and the cylinder, and two for the exhaust. These valves are periodically covered and uncovered by the piston which is its own slide valve. *Fig.* 1* shows the end of the suction stroke. The carburettor is connected to the crank chamber, in which suction is created by the upward movement of the piston and the chamber is filled with mixture. Just at the top of the stroke air is admitted to the portion connecting the chamber and the cylinder, which is thus filled with air and not mixture. On the downward stroke the inlet valve closes and the mixture is compressed slightly. Near the bottom of the stroke the exhaust and then the inlet valves are opened. The exhaust escapes, and mixture is forced into the cylinder, being diverted from the exhaust ports by a baffle on the piston. The pure air leads and saves firing the charge; it also helps to scour the cylinder. The mixture does not escape past the

* On page 413.

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exhaust ports, because it is only at atmospheric pressure at the end of the stroke. On the upward stroke the mixture is compressed and fired as usual.

The chief advantages of this system seem to be:—Reduced weight; smoother running; lighter flywheel; with absence of valves, springs, cams, etc. On the other hand it would appear that the piston rings would be liable to catch in the ports; that these would erode and so wear out the cylinder; that they would always be difficult to get at, and too much lubricating oil might get into the cylinder.* As regards the weight these engines will weigh considerably less. The power per explosion for cylinder volume will be about the same as with a four-cycle motor. But there are twice as many explosions; therefore for the same number of revolutions you will get twice the power; at the same time the fluctuation of energy will be about half. Hence the whole weight of engine ought to be about half that of a four-cycle one. These engines are built to run up to about 1,000 revs., which is as fast as most four-cycle engines run.

Engine.	H.P.	Cyls.	Engine.	Flywheel.	Total.
			cwts.	cwts.	cwts.
Hart.....	25	2	—	—	3
Ordinary	25	4	4	1	5

It is very difficult to get reliable data, so that the above must be taken as an approximate comparison.

VIII. REQUIREMENTS OF A MILITARY AUTOMOBILE.

Automobilism has grown so much of late that it is absolutely necessary to subdivide it into many branches, and the expert in any one branch has hardly time to be up to date in the others. My experience has been almost exclusively with one class, and so I shall chiefly confine my remarks to that class.

The classification I adopt is:—

(1). Tractors and long trains.
(2). Lorries and trailers.
(3). Central power transmitted through long trains.
(4). Fast light cars.
(5). Cycles.

The ways in which the above lend themselves to military use may be briefly summarized as:—

(1), (2), and (3) for supply columns, 2nd line transport, heavy guns, ammunition columns, to save infantry on the march, and to save the horses of field and horse artillery, etc.

* Mr. Lindemann now informs me that the engine will not be put on the market in its present form for this very reason.

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(4) and (5) for scouting, surprises, carrying small bodies of men or urgent stores quickly, carrying staff, orderlies, etc., and for telegraph linemen.

(4) also for carrying Generals, towing machine guns or R.E. tool carts or cable carts, etc., as trailers; and as a source of power for pumps, electric light, etc.

The chief disadvantages of automobiles of the different classes are :—

(1) and (2) are rough on the roads; (1) require wide and good roads, and (2) fair ones.

(3) are more complicated than (1) and (2), but save the roads and are an easier load for bridges.

(4) pneumatic tyres are out of the question for general military work (suppose you puncture on a greasy road, just when you want to run away); frames are not strong enough to stand rough work; the engine is invariably too low, and the wheels too small.

(5) are heavy to push, and noisy.

In my opinion, however, a military car of class (4) can be designed. Its requirements are :—The wheels should be ordinary gun wheels; the springs very flexible; the motor very powerful, quiet, and capable of running hours at full load with the car stationary; the car should have a large radius of action, and be capable of going across country, carrying with it its own gear to bridge small obstacles up to 15 to 20 feet; the motor must be at least above the level of the axles, when the springs are depressed; the low gear should be such that a man can walk up a steep hill or across a ploughed field alongside the car, and the high gear as much as nerves will stand on a medium road (probably not more than 20 miles an hour), unless a second set of pneumatic tyred wheels is carried.

There should always be on the car as many men as possible; they can help it over bad places (I never regretted picking up a peasant in Italy or Austria, where the side roads are very bad and sometimes almost impassable; and in South Africa we used to send extra men on horses, whenever possible, to help push out of mud holes, etc.; of course with large wheels the need for this will diminish). There should be a winding drum and rope to help self and others out of bad places. Last, but not least, the design should be simple, get-at-able, and easily admit of dismantling and packing in a small space for transport by sea or rail.

Such a car sounds impossible to those who only think of the present type of scorching machine, but it is bound to come for civilian country purposes as well as for military; when makers have time to think of the future they will see this. If I were agent for such a car, I could sell hundreds in Austria where the roads are not as good as in England.

Before the end of the war in South Africa we got out a design for such a car, and commenced building it. The body work can be seen

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from the accompanying *Plate*. The springing would require testing on the road before being accepted as sound, though from what one could see in the shops it seemed all right. The weight of car with engines would have been about 2 tons. Length overall 18 feet; track 5 feet 8 inches, wheel base 9 feet. Seating accommodation for up to 28 men, and a well for carrying stores. The steering was by ordinary irreversible gear, but with side lever instead of wheel, as being handier for slow speeds and out of the way; and the steering pivot and wheels were both canted to meet at the turning point on the ground and ease steering. This or a similar body might be found quite serviceable. It could be dismantled and packed into a very small space and could be very rapidly re-assembled.

In deciding on the form of transmission to be adopted in military cars, the first question to be answered is, in what countries will they be used? Presumably for us this will be in any part of the world. It is also to be presumed that there must be little, if any, alteration to adapt them to different localities. The nature of fuel, except as regards safety, is immaterial, since in most countries it will have to be specially carried.

If a petrol engine alone were used, it would be connected to a counter-shaft with differential gear through a change-speed gear, and the wheels driven by chains. If a steam engine were used, it would drive the wheels direct from chains, either using one engine per wheel or a counter-shaft with differential.

An electric system pure is out of the question. If a petrol electric system were used, the motors would drive the wheels through chains or simple gearing, one motor being used for each wheel, or only motors for the back wheels.

At present the comparison between paraffin and petrol seems to be unfavourable to the former in all cases.

As regards weight, we have to assume that we may be called upon to work at altitudes where only 50% of the power is to be obtained from a petrol engine*. The petrol engine, therefore, must have a B.H.P. of $\frac{100}{50} \times \frac{100}{80} \times \frac{100}{50} = 5$ times the average power at the wheels. In the case of a steam engine, the efficiency of the drive may be assumed to be as much as 80% and the loss due to higher altitudes *nil*, so that an engine with $1\frac{1}{5}$ times the average power at the wheels would suffice. With the petrol electric system the efficiency is $75\% \times 50\%$, which means an engine of $2\frac{2}{3}$ times the mean power at the wheels. A steam electric outfit would require an engine of $1\frac{1}{3}$ times the mean power.

The relative weights of engines, gears, etc., are rather difficult to calculate precisely, but it is assumed;—that the weights of engines and all gear varies nearly as the H.P.; that a two-cycle engine weighs a

* This would occur at about 7,000—8,000 feet.

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little more than half a four-cycle one of the same power, and a steam engine about $\frac{1}{3}$ that of a four-cycle petrol one; that the boiler is at least 6 to 8 times the weight of the steam engine; that the high altitude petrol engines have their gears designed to take their full horse power; that dynamos, motors, etc., weigh about the same as the ordinary transmission gear, this being roughly twice that of the engine itself.

As regards the petrol consumption, it is assumed that it varies with the power in petrol engines of all types, and for the same power it is the same at all altitudes; when used in a boiler furnace the consumption is about four times that in a petrol engine power for power.

As regards the starting torque it is assumed that $\frac{1}{3}$ the power can be utilized at the wheels of a petrol car, half of it in a steam car, and practically all in an electric car.

The result of the above assumptions are tabulated with the resulting relative weights of the three systems.

System.	Relative Engine Power.	Engine and Gear.		Relative Weight.	Relative Petrol Consumption.	Relative Starting Torque.	
		Weight Factor.	Relative Weight.			Abroad.	Europe.
Petrol 4-cycle, Europe	2·25	1·4	3·1	2·4	1·9	—	·4
„ „ Abroad	4·5	1·3	5·8	4·5	1·9	·4	·8
„ 2-cycle, Europe	2·25	1·1	2·6	2·0	1·9	—	·4
„ „ Abroad	4·5	1·0	4·5	3·5	1·9	·4	·8
Steam	1·0	1·8	1·8	1·4	3·3	·4 to ·8	·4 to ·8
Petrol Electric 4-cycle, Europe	1·2	1·5	1·8	1·4	1·0	—	1·0
„ „ „ Abroad	2·4	1·4	3·3	2·5	1·0	1·0	2·0
„ „ 2-cycle, Europe	1·2	1·1	1·3	1·0	1·0	—	1·0
„ „ „ Abroad	2·4	1·0	2·4	1·8	1·0	1·0	2·0
Steam Electric	1·2	2·1	2·5	1·9	4·0	1·0	1·0

REMARKS.—Column 4 = Col. 2 × Col. 3; Column 5 = $\frac{\text{Col. 4}}{1{\cdot}3}$.

The figures in Column 3 are necessarily only approximations, arrived at as stated in the text.

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With steam cars the petrol consumption is large. The extra care necessary to drive and maintain them accounts for them not being used in civil practice. Similarly petrol electric cars are practically unknown, because the extra knowledge of electricity which is required frightens people. For military purposes, however, these extra complications are more than compensated for by the diminution of gearing and the increased starting torque, reduced petrol consumption in the case of the petrol electric system, and silence in the case of the steam system.

From the above it would appear that for Europe a four or, better still, two-cycle petrol electric system would be the cheapest; for cars that have to be used at high altitudes a steam system, until such time as a two-cycle motor can be built which can be altered to run at any altitude, and then the extra weight will be compensated for by the diminished consumption of fuel. A fact which must not be lost sight of, when considering a petrol engine, is that, when running in Europe, the engine for high altitudes would be capable of doing double the work an equivalent steam one would. The petrol electric system would weigh much the same as a steam one when a dynamo was carried for supplying electric power in any of the ways suggested in I.

In considering the power required it is proposed to assume the following requirements :—

I. Travelling at 2 miles an hour up a slope of 1 in 4 on a poor road with a full load.

II. Travelling light across country.

Case I.—The tractive force required is assumed to be 400 lbs. per ton; a steam engine running at 600 revs. with a speed reduction of 6:1 is also taken as a basis for calculation.

Then $$\frac{\text{H.P.} \times 33{,}000 \times 6}{5 \times 600} = 2 \times 2 \times 400$$

and H.P. to overcome the resistance of the road is 24 to 25.

Besides this the H.P. to raise the car up the hill is

$$\text{H.P.} = \frac{2 \times 2 \times 2240 \times 2 \times 1760 \times 3}{4 \times 60 \times 33{,}000} = 12.$$

So that in the case of steam an engine of 45 to 50 H.P. will be required; this is equivalent to one of 100 or 200 H.P. for a petrol car, and 50 or 100 H.P. for a petrol electric one.

These powers are large, but such engines are used in racing automobiles, and are compact and light.

Case II.—No data of the tractive force required across country are available, but it is assumed that the conditions of Case I. are so trying that very few places would necessitate the detachment pushing or roping being resorted to.

For the Pretoria design it was originally intended to make use of the engine and boilers of two damaged cars and a spare boiler, using

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chain drives on to sprockets on each back wheel, the sprockets being connected to the wheels through springs so as to save the shock of the engine and to facilitate starting. Each wheel was thus driven separately, and no differential gear was required. This would probably meet all requirements for a steam car.

As regards a petrol electric system for the type of car suggested, it is impossible to put the motors in the wheels. Some form of reduction would be necessary; and I am inclined to think that the lightest, and at the same time the most efficient, way would be to mount the motors close to the wheels, gearing into inside teeth on the wheels, the whole being boxed in to make it dustproof. With raw hide pinions this car could be made very quiet. If each wheel had its own motor, there would be a great advantage in going over bad country; this would probably make up for the slight increase in weight. A reduction of 1 to 12, the wheels being 5 feet in diameter and the motor running up to 1,500 revs. per minute, would give a top speed of about 20 miles an hour. Were small pneumatic wheels used as an alternative, of say 30 inches diameter with a speed reduction of 1 to 2, you could attain a speed of about 60 miles per hour.

In a military car using a dynamo of the Löhner-Porsche system, an arrangement could easily be fitted to hold the field magnets in certain positions corresponding to voltages at which it might be required to work the dynamo for any particular purpose.

IX. UNSOLVED PROBLEMS OF THE PETROL MOTOR.

The theoretical study of the petrol engine seems to have been put on one side, as a result of the race to supply the demand for cars; and makers have been content to accept the motors of other firms or copy them as nearly as they can, or at the most to get at rough proportions from practical trials.

A time will come, however, when scientific institutions will take up the subject and make complete and systematic experiments. A small petrol motor does not cost much, and the experiments could probably be made just as well with small as with large engines, at any rate for the ground work.

In South Africa, when trying to master the theory of oil engines in general and the petrol engine in particular, many anomalies and debatable points came to my notice. Some of these points may have been threshed out since I studied the matter; if so, I, and possibly others, would like to know with what result; if not, some officers of the Corps may find time to go into the matter and earn the gratitude of the world at large.

To begin with fuel. What oil gives the greatest force on explosion? (1) by weight, (2) by liquid volume, (3) by volume of mixture in the cylinder.

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Alcohol is said to give better results than would be expected of it, due to the moisture contained. Some oil engines get better results by squirting water into the cylinders. But a petrol engine seems to work best in a dry atmosphere. Why ?

How does the chemical composition of petrol vary, and what is the result of such variation ? There is a great difference in petrol, even of apparently the same density.

In a carburettor, should not the oil inlet be regulated, not the air ? We want to get as full a cylinder as possible, so should not throttle any air inlet. The petrol hole is altered in some forms of carburettors. If the hole is too large, we weaken the mixture and get a carbon deposit, or petrol runs to waste ; if too small, we weaken the mixture.

Is it advantageous to dilute the charge with some exhaust products ?

What is the effect of varying the compression ? What is the best compression ? How is compression effected by speed ? It seems generally to be accepted that the greater the compression the greater the explosion ; 90 lbs. seems to be the most in use. Why stop here ? Why not use such a compression that the mixture will fire itself, as in the Hornsby-Ackroyd oil engine, and make up for throttle regulation by an auxiliary air inlet ?

What are the effects of the atmosphere ? Temperature firstly alters the density, then the quantity of moisture and petrol vapour which the air will hold. The last two effects have already been touched on, the former will follow. It may also have an effect on the temperature of mixture before and after explosion, and so affect the power which is a function of these temperatures.

By decreasing the compression space, which can generally be done by adding a plate on to the end of the piston, till you get the designed compression at mean barometric pressure, the loss due to altitude is diminished ; this is done by Messrs. Tangye to all oil engines they send to Johannesburg, and we did it to all engines we used in the Transvaal, with the result that we got about ⅔ of the power they would give at home. Now if we take such an engine from 5,000 ft. to the coast the compression will rise from 90 to 135 lbs., for which it is not designed, and the compression plate must be removed.

For military purposes we want an engine that will run at much greater altitudes, in India possibly treble, and then we will not be able to get half the power. This is a very serious aspect of the petrol engine, and requires thoroughly studying. The only way of getting over it seems to be the compression of our mixture by forced draught, or in a separate chamber to a fixed pressure, as in some two-cycle motors. By increasing valve inlets, all pipes for air and mixture, using mechanical inlet valves, etc., we may reduce the evil ; but even then we will have to devise some means of altering our cylinder volume (*i.e.*, compression space) to suit the barometer without having to dismantle the engine each time we rise or fall 1,000 feet.

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It is known that, up to a certain point, the greater the temperature of the cylinders the greater the efficiency of the motor. What is this temperature? Does it vary? Why should we not have a simple thermometer in the jacket, and keep the jacket water temperature as constant as possible by regulating our cooling fan speed or pitch?

What are the effects of altering the times and durations of admission and exhaust? How can the best adjustment be made in practice? There should always be a series of marks on the flywheel, and a pointer corresponding to the valve settings, etc.

How does the pressure rise after ignition? Does it vary with different forms of ignition, with varying compression, cylinder temperature, and mixture?

Is a series of sparks any better than a single one? A long than a short one? A high tension than a low tension one? What is the best tension?

It is claimed for magnetos that as the engine speed increases so the time of ignition is automatically advanced. Is this so?

Besides the above it would be extremely interesting to have records of the tractive force required with different wheels and tyres on bad roads (*i.e.*, bad from a military point of view).

HART TWO-CYCLE MOTOR.
(*See page* 405).

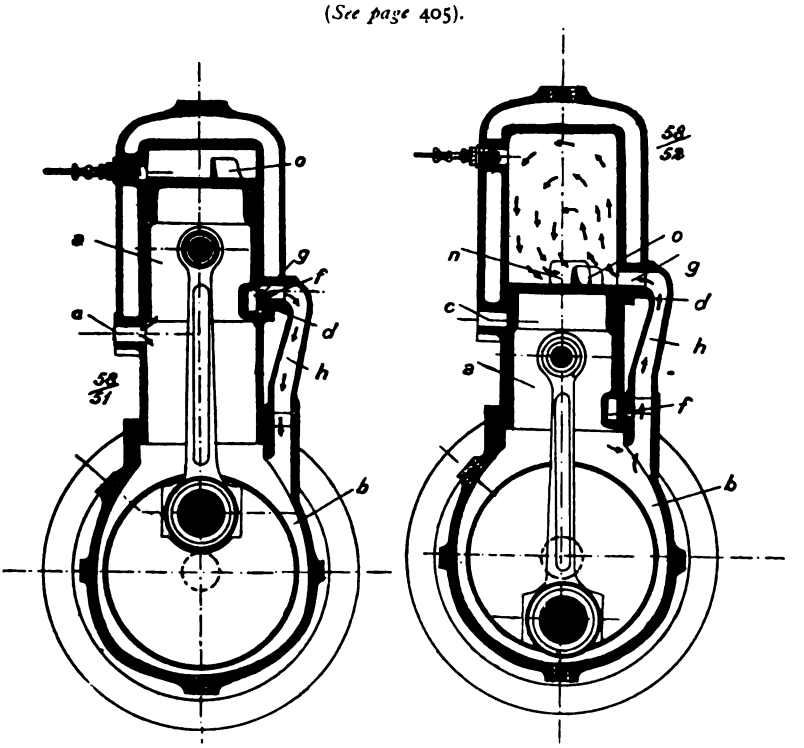

Fig. 1. *Fig.* 2.

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TRANSCRIPT.

THE JEWELL SYSTEM OF FILTRATION OF WATER, AND ITS APPLICABILITY TO INDIA.*

Extracts from Report by MAJOR P. E. DIXON, R.E.

THE Jewell System of Filtration of Water is a process of mechanical filtration, first introduced in America, and consists of the utilisation of a coagulent to precipitate the impurities in the water, and also of mechanical devices for the cleansing of the filtering medium.

The system has been largely adopted in the United States and Canada, no less than 200 towns now employing it. It is being gradually introduced also on the Continent of Europe and elsewhere. There are two installations in England, at York, where however it is not utilised to the full extent, and at Wolverhampton. There is also an installation in India, at the Kolar Goldfield in Mysore.

There are three principal methods of water purification,—coagulation, subsidence, and filtration; and the Jewell system is a scientific attempt to combine the three in one system. The coagulent employed is sulphate of alumina; a weak solution is added to the unfiltered water, the sulphate of alumina is decomposed and hydrate of alumina is formed, a gelatinous flocculent precipitate of greater specific gravity than the suspended particles in the water. The larger flakes of this gradually settle down in the subsidence tanks, carrying with them from 40 to 75 per cent. of the suspended matter and bacteria. The finer flakes remain and enter the filter where they are retained by the upper layers of sand in the filter bed; and they there form a gelatinous film which takes the place of the natural organic film that forms in the ordinary slow sand filter and performs such an important part in the operation of filtration. Thus the use of the coagulent fulfils two objects—first, the precipitation of the greater part of the impurities in the subsidence tank, and secondly, the formation of the gelatinous film necessary in the sand bed.

With the aid of these two actions of the coagulent it is found possible to accelerate the rate of filtration to an extraordinary extent: while the ordinary sand filter will pass from 50 to 75 gallons per square foot per day, this process will pass as much as 2,000 or 3,000 gallons.

* Communicated by the Director-General of Military Works in India.

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This of course necessitates much more frequent cleansing of the filters When the filtering film has become too thick and dirty for filtration to be economically continued the sand bed is washed: this is done by reversing the flow of water and forcing a back current of filtered water upwards through the sand, which at the same time is violently agitated by revolving rakes, so that all the deposited film is removed with the accumulated dirt and the sand particles are thoroughly cleansed and restored to their former purity. The filtration is then resumed, and after a very short time a fresh film forms on the sand bed and the filtrate is as good as ever.

A solution of fixed strength is prepared beforehand and added to the unfiltered water mechanically in any proportion desired. The proportion used may vary from ¼ to 6 grains per gallon, according to the turbidity of the water or the rate of sedimentation required. Sulphate of alumina alone is now generally used and it is more economical than common alum. There is no danger whatever to health in its use as it is practically all precipitated and left behind in the subsidence tank.

The filtering medium is sharp river sand, 20 to 40 meshes, and the average depth is 4 feet. A large filtering head is required, from 6 to 14 feet; this results in the compacting of the sand bed, making it almost sandstone. Only 2 feet or so is carried above the sand bed, the remainder is negative head which is found to give better results.

From the bacteriological experiments, conducted everywhere where the system is in use, it is found that it is most efficient in removing bacteria.

Type of Jewell Filter.—Mechanical filters are of two types—*Gravity*, where the water passes through the sand bed by the action of gravity, and *Pressure*, where it is forced through by pressure. Both have their advantages. The Jewell filter is of the former type. Its distinctive features, as compared with other mechanical filters, are the agitating device for raking the sand bed during washing; and the weir wash device by which the upward flowing wash water, with all the suspended dirt and impurities, falls over the edge into an annular space surrounding the filter. The sedimentation basin may be attached to the filter or may be a separate basin elsewhere; where the water to be filtered is excessively turbid, both are desirable.

A type drawing of a Jewell filter with subsidence tank underneath is attached, showing the whole of the mechanism of the interior. The filter consists of two concentric cylindrical tanks of hard wood, the inner one containing the sand. Iron or steel or masonry can be used instead of wood if desired. The inner or smaller tank only extends half way down the interior of the outer or larger, and the lower portion of the latter forms the sedimentation basin. There is an annular space between the outside of the inner tank and the upper part of the outer, and the top of the outer tank is also higher than the inner one. The inner tank rests on a ring round the interior of the outer tank, and there is no communication between the annular space and the sedimentation basin below. At the bottom of the inner tank is arranged a system of bronze strainers below the sand, through which the filtered water flows. In the centre

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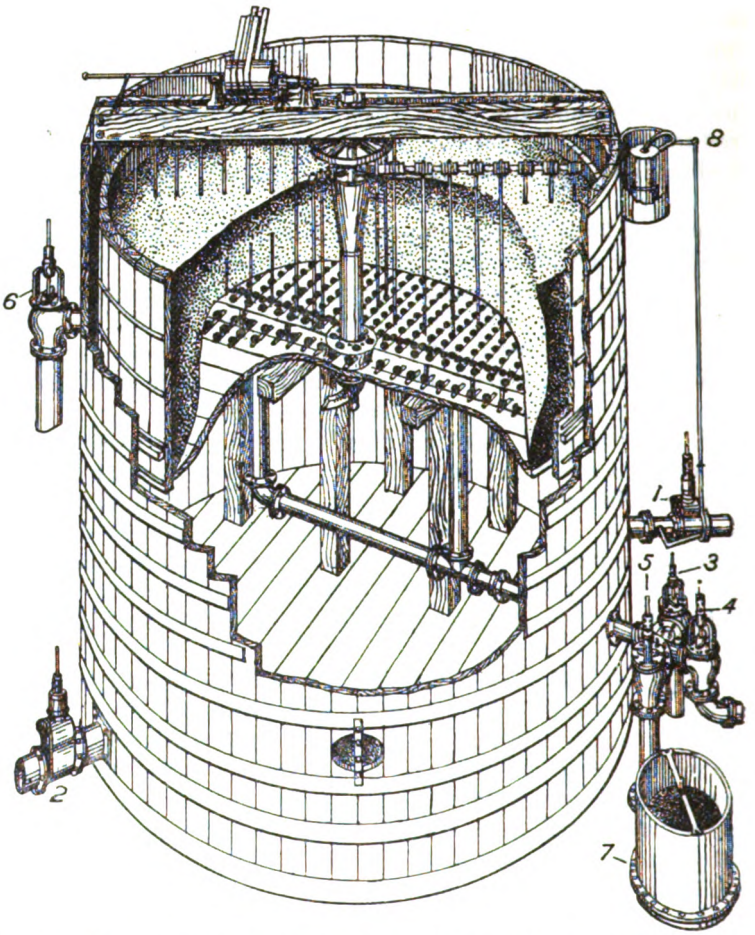
of the tanks is a pipe communicating from the sedimentation basin below to the top of the sand bed.



1—Inlet Valve. 2 and 6—Washout Valves. 3—Rewash Valve. 4—Wash Valve.
5—Delivery Valve. 7—Weston Automatic Controller. 8—Regulator.

15 FT. DIAMETER JEWELL GRAVITY FILTER, WITH SUBSIDENCE BASIN.

Above the tanks is the agitating apparatus. This consists of a revolving beam, carrying two rakes with the teeth so disposed that when the apparatus revolves in the forward direction they are rigid and dig down into the sand, but when the motion is reversed they bend up on hinges and drag along the surface without penetrating. The tanks are in communication with the outside by means of a number of valves for the ingress and egress of the water, the uses of which will now be described.

Process of Filtration.—When the filter is working in the ordinary way the valves 1 and 5 are open and 2, 3, 4 and 6 are closed. The unfiltered water, with the sulphate of alumina added, enters by valve 1, fills the

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sedimentation basin below, and, flowing very slowly through it, deposits the greater part of the alumina with most of the impurities and bacteria. It then rises through the pipe up the centre and overflows on to the top of the sand bed; the remainder of the alumina is deposited and forms a film, and the water filters through this and the sand bed, and through the bronze strainers below, to valve 5, and thence to the clear water storage tank, Valve 5 is fitted with a special apparatus, called the "*Controller*," marked as 7; this automatically regulates the discharge of the filter so that it can be varied according to requirements. The water is allowed a head of about 2 feet above the sand bed, and this is fixed automatically by a "*Regulator*," shown as 8, which is connected with the inlet valve 1.

Process of Washing.—When the filter has worked a certain time, usually 24 hours, it gets clogged and has to be washed. Valves 1 and 5 are first closed, and valve 6 opened. Valve 4 is then opened and filtered water pumped in through it: this water passes backwards along the outlet pipe and upwards through the bronze strainers and the sand bed, rises above the latter and, overflowing over the top of the inner tank, falls into the annular space and is carried away by valve 6. At the same time the rakes are revolved, thoroughly stirring up the sand and allowing the water to circulate entirely throughout it and cleanse it completely. At first the water comes out thick with mud and dirt, but after five or ten minutes it becomes clear again and the washing is complete. The revolution of the rakes is then reversed until they rest on the surface of the sand bed without penetrating. Valves 4 and 6 are then closed and 1 opened, and the filtration is resumed. The filtrate is run to waste through the "*Re-wash*" valve 3 for the first half hour, to allow time for the gelatinous film to form on the sand bed and come into operation again. Valve 3 is then closed and valve 5 opened and the filtrate run into the clear water tanks for use.

Washing of Subsidence Basin.—At certain intervals it is necessary to remove the deposit from the subsidence basin. This is done mechanically at the same time as the washing of the filter bed. Valve 2 is opened and the subsidence basin emptied. Valve 6 is kept closed, so that the wash water cannot escape by the annular space between the tanks, but rises until it overflows with violence down the central pipe: this ends in a curved shoot which can be revolved, and the wash water is thus projected all round the interior surface of the subsidence tank with such violence that all the deposit is washed away and carried off by valve 2.

Sterilisation.—In spite of the washing, the sand grains in process of time collect an organic coating, particularly if the unfiltered water carries with it any oil or greasy matter. This can be removed in a few hours by placing a small quantity of soda ash on the surface of the sand bed, and forcing in live steam through the wash valve 4, so boiling the sand bed with alkali and removing all traces of organic matter. This is only required from one to three times a year.

Installation at York.—The supply of water at York is taken from the river Ouse, which during floods is liable to become extremely turbid. Up to 1899 this water was filtered by the usual process of subsidence reservoirs and slow sand filters; then the supply was found insufficient

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and extensions were proposed; but after exhaustive inquiry it was found cheaper and better to introduce "roughing" filters on the Jewell system between the existing subsidence reservoirs and the filter beds. No coagulent is used, as the sedimentation takes place in the subsidence reservoirs, and the filtration through the gelatinous film is provided in the slow sand filters. The Jewell filters are made of cypress wood, bound with iron hoops, and they are 17 feet in diameter and 10 feet high. Quartz sand to the depth of 4 feet is placed in each filter, and the unfiltered water is delivered by gravitation from the subsidence reservoirs on to the top of the Jewell filters, and flows through them, also by gravitation, on to the slow sand filter beds at a lower level. The washing is carried out every 24 hours with rough filtered water and takes about 15 minutes.

Originally four filters with a capacity of 3,000,000 gallons per day were erected, and now three more have been added.

Installation at Wolverhampton.—At Wolverhampton the water-supply was derived from deep wells of exceptional purity in the valley of the Cosford Brook, but in 1901 the supply was found insufficient and the water of the brook itself had to be drawn upon. This was frequently turbid and of course required filtration; so two Jewell filters with a capacity of 1,000,000 gallons per day were erected. The water is drawn from the brook and delivered to the filters by pumps. After treatment with 1 grain per gallon of sulphate of alumina the water flows through the subsidence tanks and filter beds to the clear water tank. The rate of filtration is 2,900 gallons per square foot per day, and the filters are washed every 12 hours. The pumps are worked by two small electric motors, and another one is employed to drive the agitating rakes. The filters are almost automatic in their action, only one skilled workman being employed to look after the pumps, motors, and generators, to mix the coagulent, and to superintend the filters.

Installation in India.—The one installation of the Jewell system at present in operation in India is at Bethmangala in the Kolar Goldfield under the Mysore Government. It consists of four Jewell Export Filter Company's gravity filters of a capacity of 2,000,000 gallons per day, with the necessary pumps, etc. The water is pumped from an artificial lake to a specially constructed subsidence basin, from which it flows by gravity on to the filters. One grain per gallon of sulphate of alumina is used as the coagulent, and the process is as already described.

Cost.—It is practically impossible to give any useful figures as regards the cost of installation or maintenance of this mechanical filtration. The accessibility of the place, the turbidity of the water, the value of the land, and the local cost of labour and material, are all factors which operate to cause wide variations.

Comparison of Systems.—The following advantages over the slow sand system of filtration are claimed by the Jewell Export Filter Company for their filters:—

1. Capacity to treat very turbid water.
2. Capacity to remove a large percentage of colour.
3. Occupy a relatively small area.

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4. Protection from weather, frost, etc.
5. Freedom from risk of vegetable growths.
6. Rapid and easy cleansing without risk of contamination by workmen.
7. Sand bed easily sterilized.
8. Absolute control of each separate filter with knowledge of its condition.
9. Water can be sent straight to the consumer with the least possible delay.
10. Adapted for treating water for hardness, plumbism, or removal of iron.
11. Reduction in size of subsidence tanks.
12. Facility of construction and extension.
13. Low initial cost.
14. Low cost of maintenance.

Adaptability for India.—There seems no reason why the Jewell system should not be as suitable for adoption in India as elsewhere. The advantage of requiring less space than the slow sand system is, however, not likely to count for much where land is cheap. Also the mechanical appliances and skilled staff required for this system are a disadvantage in a country where skilled labour is expensive and difficult to obtain, while the unskilled labour required for slow sand filters is just the reverse. The only method to adopt in deciding as to the suitability of this system in India is to treat each place where the filtration of water is required as a separate case, and to consider the comparative advantages of the two systems on their own merits.

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REVIEW.

TACTICAL INFERENCES FROM THE BOER WAR AND THE GROUP ATTACK.

By A. von Bogulawski, Lieut.-General.

The author in his preface lays stress on the immutability of the fundamental principles of war. He insists on the interdependence of the arms of the service, so that one cannot be neglected without detriment to the others. But infantry must always carry out the preponderating part in the fight; and so military leaders as well as writers have unceasingly striven to discover the most favourable form for the attack, acknowledged to be the most difficult part of infantry tactics.

It was thought that some definite conclusion had been reached when the War in South Africa, 1899–1902, appeared to introduce new elements for consideration.

Chapter I. is a sketch of the development of German infantry tactics introduced from time to time as the outcome of the experiences of the War of 1870–71.

At first the preference was for strong lines of skirmishers, composed of complete sections; these were followed by supports in ranks at open intervals, with groups closed or at open intervals. Advance was to be by rushes of 50 to 80 paces. But it was soon recognized that supports, deployed in open formation, were a danger to the firing line, and so these formations were suppressed;—rushes were reduced to 50 to 60 paces.

Then came various measures for fire discipline, prescribing when volleys were to be used, and when independent fire, with a named number of rounds.

About 1877 long range fire was advocated; but after some time opinion reverted to the principle that, in the attack, firing should be postponed till within the shortest possible range.

Then came the regulations of 1888, which forbade a normal form of attack, giving merely general indications for guidance but more or less prescribing a strong firing line. Cohesion of the final rush was to be ensured if possible by the direct command of the Officer in Chief Command. The mixing of units was to be avoided as much as possible, but troops were to be trained to fight in any formation or fronting the wrong way.

Constant improvements in guns and rifles prevented the subject being put aside, and, as usual in peace time, very erroneous and misleading conclusions were evolved. A tendency arose to insist too much on the ballistic and technical element, to the neglect of the tactical one and of psychological conditions. This resulted in the advocacy of wider extension, and, while still adhering to dense skirmishing lines, an endeavour to compass enveloping attacks that diminished the depth of the attacking force and added materially to the difficulties of supreme

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command. Then came the idea that salvation lay in enveloping the defender and establishing superiority of fire; the fire fight was to be the only arbiter, and some went so far as to declare an attack across the open to be impossible. Next came the view of a highly placed Officer, who maintained that superiority of fire was only to be obtained by the skilful exchange of the strategical for the tactical *rôle;* that is the concentrated advance of several columns endeavouring to converge their fire.

The opinion was even advanced that a sort of siege practice should be adopted, and advantage be taken of nightfall for the attackers to dig themselves in. The author contests this idea; and considers that every great leader has endeavoured, and will endeavour in the future, to end a fight when possible in a day. History proves that this has frequently not been the case.

He disputes the idea, now advanced, that the defence has gained anything by virtue of improved weapons, which, he contends, augment the power of the offensive in like proportion.

"Even with the oldest blunderbusses the defender had the uncontestable advantage, when in a previously occupied or at all fortified position, of using his piece more coolly and accurately than the attacker who was more or less in motion. The same applies now. How can circumstances have changed when the weapons on both sides are approximately the same?

"In the beginning of the attack, in the pause in the fight (which is a characteristic of war at present), finally in the rapid fire preceding the final rush, the prospects of the attackers are the same as ever. It is only when the attacker does not know how to use his weapons, or attacks clumsily, that the new weapon bestows on the defender a durable superiority. By clumsiness we mean unsuitable formations, improper use of ground, and defective fire preparation.

"One point must not, however, be left out; that is, the moment when the attacker makes his rush without firing, either in the final storm or in one of his so-called 'forward springs,' or even in the bringing up of supports, then the rapidity of fire and low trajectory of the projectiles claim their advantage and cause in a short time a large number of casualties and consequently have great effect. The art of the attacker consists in not letting his fire dwindle, even though he cannot produce the same effect as the defender. At this moment it is not possible completely to balance the defenders' fire."

But to counteract this the author has an expedient of his own, which consists in firing without halting in the advance.

He does not believe in the endeavour to balance the superiority of the defence by importing measures of fortress warfare into the field. "True! the possibility of digging-in at night has been proved on manœuvres, when a position some 450 m. from the defenders has been entrenched." But, he asks, "Who is the enemy who will allow working parties in front of him at that range, without destroying them by fire or even by a sortie immediately their presence is reported by his patrols?"

He then draws a comparison between siege warfare and field warfare, pointing out that in the former the first infantry position is 1,000 m. and not 450 m. from the enemy, and that if the attacker can get to within

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450 m. the defender is probably worn out. Digging-in at this range only leads to fruitless night fights and renders a part of the troops incapable of action next day.

It is quite a different thing to secure important points at some distance from the enemy, or artillery positions. But to recommend siege measures on the battlefield as of general application to overcome the difficulties of the attack appears to be a mistake.

Chapter II. begins:—"The tactics of a campaign bear the imprint of the prevailing strategical idea," and the possibility of strategical offensive in combination with tactical defensive in general is denied. Of course defence is never devoid of offensive incidents, and attack is not all offensive but comprises some defensive incidents; and to be able to change one attitude for the other betokens the skill of the subordinate leaders.

"The Boers advanced into Natal on the strategical offensive, but they were not tactically offensive in any great action. They took up position and beat off the attack with great success; but did not use their advantage, and so produced no result. The attempt of Joubert on Pietermaritzburg came utterly to grief.

"Nevertheless some consider that this conduct,—which was purely traceable to the absence of a thoroughgoing strategical thought to make use of the initial superiority of force with united forces in one direction—was a new practical incorporation of the idea 'Strategical offensive—tactical defensive.' The impossibility of this procedure was sufficiently manifested in the course of the war. The strategical advance snuffed out, and we soon saw the Boers thrown back on to the strategical defensive, in which in the end they succumbed. This was the position of affairs to the attentive observer at the turn of the year 1899–1900."

The author does not think the Boers' conduct of the Campaign was incorrect in the circumstances when the leaders found that their forces were not adapted to great tactically offensive movements. "A Bonaparte or a Frederick might perhaps have succeeded with this mob in carrying out an attack with concentrated forces on Durban or Cape Town and in teaching them the offensive by victory—but Joubert was not a Bonaparte."

From October, 1899, to the arrival of Lord Roberts the misapplied strategy of the Boers failed completely, even when opposed to "the in many ways unskilful tactical attacks of the English." A comparison is drawn between the prescriptions of the English and German drill books, in which there are few divergences, owing to the influence the latter has had on the former.

"However, the English had become accustomed to fight savage or half-civilized peoples, whose attacks they shattered with ease. That the training of the English infantry in the use of ground and in shooting was not up to the mark is well known. The English officers belong to the cultured class and their heroism is unquestioned, but their knowledge of war and practical training leave much to be desired. Training of leaders and troops can only be carried out by exercises and manœuvres in accidented country and not by drilling in garrisons. The English, whose laws forbid trespass in the country, which belongs to private owners, were in the same condition as the French before 1870, who were only able to

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manœuvre at Châlons. The English army is above all a recruited army, and the ranks hold many unworthy elements; nevertheless it is a national levy, and in the ranks is implanted the consciousness of belonging to the great English Empire, to that race which, by its power and tenacity, has overthrown many hundred millions of other races and held them in subjection. All the more remarkable is it that in the course of the war many weak elements have become apparent."

"Opposed to it was a quite exceptional army. A modern militia, as it has been called by the lovers of militia, it certainly was not; but it was the levy of a warlike people, whose physical and moral characteristics differentiate it from European nations. The older generation had been in conflict with the English, the younger with the native races, and were trained by these experiences and especially also by hunting to be good shots. Hardened by work and toughened by fatigue the Boers also enjoy magnificent eyesight. Their feeling towards the English was that of the victors of 1880, towards the natives that of masters. But they lacked organization and discipline—not every man left the 'Laager' to take his place in the shelter trench, and many disappeared at times to go home and tend their farms."

The Mauser was superior to the Lee-Enfield; the artillery, however, largely composed of Q.F. guns, was far inferior in number to that of the English. The peculiarities of the country are duly noted and insisted upon, because "they must be properly weighed in gauging the tactical conditions."

Chapter III. is an examination of some of the fights in the Boer war. The middle of October, 1899, found the Boers crossing the border mountains in several columns into Natal and moving concentrically on the English camps at Glencoe and Ladysmith; strength about 20,000 against 9,000 British at the two places named and some 3,000 at Durban and Maritzburg. Some 12,000 Boers were operating against Kimberley and Mafeking. A weak force had pressed into Cape Colony.

The author then describes and comments on certain engagements, selected as being representative. Amongst others:—

Colenso (15th December, 1899).—The forces engaged were reckoned as:—English, 15,600 and 44 guns, including 14 naval; Boers, variously reported as 3,000 and 5 guns, not over 5,000, and 10,000. The British losses, excluding missing, were 143 killed, 756 wounded, total 899, or 5·8%. Erstorff gives 70 officers and 1,040 men, of whom 28 and 203 respectively were prisoners; Müller counts 1,197 men and 66 officers, of whom 15 and 348 were prisoners; Gilbert gives 1,300. "The Dublin Fusiliers lost 23·9%, the Connaught Rangers, 16%. Compare this with the loss of 54% by the *Garde Schützen* battalion at St. Privat; the 1st Battalion 50th Regiment at Wörth, 43%, 16th Regiment at Mars-la-Tour, 68%, the 52nd, 52%. Moreover the regiments of the Guard Division at St. Privat and the 10th Division at Wörth each lost quite as heavily as the whole of Buller's corps at Colenso. These figures speak volumes. They disclose the fact that the fire effect of the newest weapons cannot possibly be taken so high as credited to them by the experience of the rifle range."

Spion Kop (23rd–24th January, 1900).—The British losses are put at

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1,437 killed and wounded, equal to 7% of those engaged. Gilbert gives 1,150 men. Prisoners and missing are included. Assuming 1,000 lost out of a possible 5,000 actually engaged on Spion Kop itself, this gives 20%. Lindenau says the Royal Lancasters and Lancashire Fusiliers lost 17 and 17·2% respectively. The author says: "The losses were not inconsiderable, but still they fall much below those suffered by the Germans in the war of 1870. That the English failed is not traceable to the effect of modern weapons, but to bad leading, unfavourable ground and conditions."

Modder River (28th November, 1899).—The forces engaged are put at:—British, 9,000 men and 22 guns including 4 naval; Boers, about 7,000 men and 10 guns. The British losses were 24 officers and 462 men, or about 5⅗%. Boer losses variously reported as 100 and 350 men.

Magersfontein (11th December, 1899).—British, 12,000, of whom 9,000 only were engaged; Boers, 7,000. The British losses were 895 killed and wounded, something over 7%; one battalion of Highlanders lost 35%, the other 23·4%. Boer losses variously stated at 200 and 600. The author's criticism on this fight is very severe. The night attack was planned beforehand and was directed against the left flank of the Boers. But as the reconnaissance was *again* thoroughly defective the attack was in the wrong direction. Had the left flank of the heights been taken the remainder of the Boer position would have been untenable. He considers our formation to have been bad, and the attempt to deploy under fire disastrous. A close formation, he admits, was requisite to keep the troops in hand in a night attack; but he holds it unnecessary to jam two battalions close up to one another in a compact mass, and pronounces it out of the question to advance without a few scouts some 50 to 60 paces in front. At the first outburst of fire the troops should have dashed to the front and overrun their enemy without waiting to deploy. The numerical superiority of the British artillery did not make itself felt and the Boer device of refusing the artillery duel proved a valuable expedient for the defender. The British cavalry might have found something to do far out on the flanks. As at Spion Kop, if the Boers had made a vigorous counterstroke they would probably have destroyed the bulk of the British force.

The second phase of the Campaign began with the arrival of Lord Roberts. Strategically it is marked by the advance against Cronje, whose rounding up and capture compassed the relief of Kimberley, Ladysmith, and Mafeking, the capture of Bloemfontein, the advance to and occupation of Pretoria, and the movement of Buller into the Transvaal.

"The strategic movements of the British were conducted with firmness and decision. Tactically the British front was often over-extended, and an European opponent would have attempted to break through; but Roberts had thoroughly gauged the Boer lack in offensive tactics. The bootless strategical position of the Boer leaders, who had been carried away by their desire to capture Ladysmith, was brought into its true light by the course of the second phase of the Campaign."

The third phase is dismissed in a few words as the engagements contribute no evidence of value to the author's object; but it is worthy of

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notice that "The Boers remaining in the field eradicated in a great measure the defects of their forerunners, viz., lack of discipline and offensive power. The Commandos were organized in companies and these again in sections. The election of officers was abolished. There is not much to be discovered in the way of a so-called 'Boer attack'; but there were many cases of plucky sudden assaults, such as Tweefontein, 24. 12. 1901, and Tweebosch.

"The Boers had become robust and well-proved soldiers by long continued fighting; on the other hand the British, who at length were obliged to turn out 300,000 against this small people, had a large proportion of badly trained worthless troops. Nevertheless the traditional stubbornness of the Anglo-Saxon race and its innate patriotism manifested itself as of yore, and the terrible difficulties involved by locality and climate must not be forgotten."

Chapter IV. discusses the inferences from the war. The first was that the *Frontal attack is no longer possible.*—The author contests this; saying, "It is not alone the modern firearm that has caused the repulse of the English attacks, but faulty direction, deficient leading, also (often) insufficient energy in pursuing the fight and want of systematic arrangement. Unsuitable formations, special nature of the enemy and of the terrain also played a great part. It is not to be denied that, in many moments of the fight, the volume, range and rapidity of the Boer fire became a preponderating factor; but we do not think to err in stating that the results would have been identical with the single loader. Indeed it is possible that the same results would have ensued had the defenders been armed with muzzle loaders. How often the above-mentioned factors of terrain, leading, etc., have been the deciding ones all history of war shows. So, in proclaiming the combination of front and flank attacks to be the best, it is an error to characterize the frontal attack once and for all times to be impossible."

The second inference was that *Our tactics of attack must be changed.* This the author contests vigorously, alleging against it the numerous false inferences drawn from the experience of former wars. "Let this be a warning not to draw conclusions or to introduce forms which are based more on superficial notice than on well-formed conception of war and a knowledge of its ruling factors. This exhortation becomes more and more in season as actual war experience diminishes in the army."

Chapter VI. deals with practical results and experiments in Germany. It is very difficult to give a *précis* of this part, in which the author falls heavily on several would-be reformers, and criticizes their deductions in detail as follows:—

THE ATTACK.

(1). *Conduct of Skirmishers.*—He objects to creeping forward and running from cover to cover. "It demands individual heroism to leave cover. To move on alone and uncheered by companions produces more hesitation than witnessing casualties, which are better endured in company. The number of 'hesitaters' will increase in a greater proportion

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than the casualties due to the enemy's fire. The 'Living Survivor' is often more encouraging to the retreating comrade than the 'Brave Dead.'"

He objects to the thin line of skirmishers altogether; and says the defender will probably not fire on it, or will drive it back by similar thin lines or else sweep it away by mass fire or brush it away by counter-attack. The point is that a thin line cannot produce sufficient fire effect, moreover the constant advance of reinforcing groups will equalize the losses with those of an originally thick line. He objects to the section and group leaders lying down, and treats the idea of an officer lying down with great scorn.

(2). *Bringing up the Supports.*—The author seems to think that Company Columns, being separated by large intervals, offer a smaller target to shrapnel than men scattered all over the field. He objects altogether to deployed second lines, who are certain to shoot their comrades in front.

(3). *The Final Rush.*—The Boer War has further established that the final rush is the most difficult part of the attack. Eye-witnesses state that the attack was often shattered close in front of the defenders.

"The reformers wish to dispense with drums and bugles, so as not to attract the attention of the enemy. In advocating this they are setting at defiance the experience of many thousands of years; for in no other moment are the clear word of command, the bray of the horn, and the roll of the drum of more importance."

"The storm should not be begun till the defence is shattered, but this moment is not always recognizable. The pause in the defender's fire, to deceive the attacker, is one of the lessons worth learning from the Boer War, although it has often been practised before, especially by savages." The theory is contested that the enemy should be driven out of his position by fire effect without a charge. "The enemy cannot be driven out by fire alone, but he must be stormed out; otherwise, a couple of dozen skirmishers might keep an attacker at bay by magazine fire while the main body makes good its retreat. A storm must be carried out, and the Boer War tells us that delay under fire is probably as costly as a rush. The way out of the difficulty consists in 'Firing on the march.'" Such firing is objected to because it must be unaimed; but firing at 1,000 to 1,500 m. ranges is also unaimed, and yet it is not objected to.

Chapter VII.—Extent of front and battle tactics.—The author objects to wide extensions; and, after citing many instances from 1870, confirms his objection on the grounds that wide extensions add enormously to the difficulty of command, especially as regards bringing the reserve into action at the critical moment. Extensions wider than 150 m. for the company and 400 m. for the battalion are not advisable.

Chapter VIII.—Moral springs of action—Use of fire—Tactical and fortificational rules of defence.—The author bewails the degeneracy of the race, and traverses the opinion that men should be given more latitude and initiative. He doubts that the Boers are better marksmen than the Germans, but their merit lay in "No waste of ammunition,—shoot at short range." The wide deployment of the Boers is only to be copied on rare and exceptional occasions. Except in a few isolated

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occasions the Boers were always on the defensive. The spirit of attack was only manifested in the guerilla stage.

Chapter IX. contains notes about the other arms.

ARTILLERY.

The lesson to be learned is not to overestimate results by experience of the artillery range. The single gun emplacements of the Boers were suitable to their tactics. Shields must give way before steel-bulleted shrapnel; the shielded Boer guns held their own against inferior unarmoured pieces. The defender in a well-fortified position does well to decline the artillery duel and reserve his fire for the infantry attack. The occupation of artillery positions without previous reconnaissance, as at Colenso, leads to disaster. The union of the arms must be preserved, and infantry must press on and get engaged so as to make the defender disclose his position.

CAVALRY.

The author does not think much of the English cavalry. They only delivered one charge, and conducted reconnaissance with incredible carelessness. But they did well in turning movements in the advance on Bloemfontein and Pretoria, also in the relief of Kimberley. Reviewing the latest prescriptions for cavalry, he thinks the English have gone too far in depreciation of the cavalry charge. Scouting and reconnaissance are much more difficult since the introduction of smokeless powder, so scouting cavalry must often resort to the dismounted fight to arrive at reliable information. This is one of the most tangible lessons of the war.

SAPPERS.

That sappers can be dispensed with the Boers have taught us. Still the sappers must be the teachers of the infantry, and should therefore bestir themselves unceasingly to perfect the practical adaptation of field fortification. For this, thorough tactical comprehension and knowledge of shooting are indispensable. The concealment of trenches is always to be kept in view, and practical experiments with ball cartridge should be carried out to ascertain to what extent tiers of fire trenches may be used. The Boers had no engineer officers and so formal attacks on Kimberley, Mafeking, and Ladysmith were out of the question. They were right to evacuate Pretoria; for had they held it, they must have concentrated all their available forces there. The English would have besieged *en règle* and brought the war to an end with the fall of Pretoria.

THE TRAIN (A.S.C.).

Laudatory in every respect.

SUMMING UP AND CONCLUSION.

1. A frontal attack over the open is difficult, and therefore to be avoided as much as possible. It is in no way, however, to be considered as impracticable with proper troop leading and adequate preparation.

2. The tenet that open spaces under hostile fire cannot be crossed is mischievous, tending as it does to weaken the spirit of adventure.

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3. Advance by groups is permissible in special natures of *terrain*, and especially in small actions or in incidental combats of a great fight. This must not be confounded with the proposed *Group Attack*, which, generally speaking, involves too wide an extension in battles, reduces the influence of the leaders, and introduces a premature confusion of units.

4. Initial fire power is too feeble (alluding to thin skirmishing lines). Reinforcement by driblets does not help matters. Therefore, whatever be the *terrain*, strong shooting lines should be developed from the beginning; these to be brought forward in section rushes, requiring careful practice. The distance of each rush in open ground to be not less than 50—60 mètres, in broken or hilly country according to localities.

5. Reinforcing detachments, according to circumstances, help with their fire or carry along the shooting line with them.

6. In the open the storm to be delivered at a charging pace with magazine fire on the march. Bayonets to be fixed at 500–600 m. from position. The last 30–40 mètres to be covered at the run without firing.

7. The units of the second and third lines follow, neither in groups nor in extended lines nor in ranks nor sections (unless an obstacle necessitates such formation), but in Company Columns or in line. In this way as the 2nd Section is behind the 1st, a line of half the length is formed. The closed bodies of the 1st line (supports) keep about 200 m. behind the firing line.

8. The units told off for the storm must however be brought close up to the firing line, unless the firing line itself breaks away by its own initiative and, seizing a favourable moment, carries the position with a rush.

9. It is permissible to increase the extension of the company to 100–150 m. and of the battalion to 400. Should circumstances demand the development of full fire power every man of the battalion can fire.

10. To fire at the shortest possible ranges is to be impressed continually on leaders and troops. No need therefore to lay down a range.

11. For superior officers the principle of "Strong Reserves" is to be continually rubbed in. The art of Napoleon I., to wait for the throw till a crisis is manifest, must be again brought to life.

The writer concludes by remarking that his experience covers the period from the smooth-bore musket to the magazine rifle.

As this pamphlet embraces a large measure of criticism in leading up to its inferences, it has been thought indispensable to review it at length in deference to the position and reputation of the author. It is to be regretted that the descriptions of the actions are illustrated by very indifferent sketches of the battlefields; the imperfections are traceable in the rendering of the story. Criticism of so high an authority as the author is not to be ventured on with impunity; but it seems to the translator that he has not quite caught the atmosphere of the veldt in the picture he draws of the engagements and their attendant circumstances. To say that all will agree with the inferences drawn from the South African campaign would be to assume surrender of independent thought to the moral influence exercised by an eminent military writer.

J. A. FERRIER.

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NOTICES OF MAGAZINES.

Engineering News.

September 14th, 1905.

Double-Tracking of Railways.—This number has among its contents two articles containing some observations on this important subject. Considering that of the American railway mileage only some seven per cent. has two or more roads, it is at once seen that there is a likelihood of much doubling work having to be done. The New York Central, by the way, has the most double line.

Up to the present the tendency has been to work trains on a single line up to the absolute maximum of capacity before having recourse to a second track, but managers are inclined to consider whether this is the most economical course. It has been generally assumed in America that the limit of economical capacity on a single line is some 50 to 60 trains daily (including a proportion of passenger trains), if the line is well provided with sidings. But the *possibility* of handling such a number of trains is a different affair from the most desirable and profitable service.

Some calculations which were brought before the Railway Master Mechanics Association in June last shewed surprisingly what a large proportion of the working hours of an engine working on a single line was apt to be spent in sidings waiting to pass trains, and unless traffic can be kept running very regularly delays of this nature must be considerable when the density has reached a certain pitch.

The regulation of traffic has, in fact, a very important bearing on the question of double-tracking. Short sections of double line at some points may enable crossings to be made there with a comparatively large margin of time, and certain lines, just as the Cape Government Railway has done, have adopted the expedient of doubling their road on each side of junctions so as to relieve and obviate congestion at those centres. Again, certain lines which have alternative routes have adopted the plan of using one line for up and the other for down traffic; or indeed there may be several routes, a very useful thing in case a rush has to be handled.

Where double-tracking has actually been decided on, the question of the most advantageous alignment comes up. Sometimes an entirely fresh double line may be constructed to shorten the route or obtain better gradients; or again, if the existing line is favourable to traffic in one direction it may be feasible to site the new one so as to favour traffic the other way; but the capital cost of simply widening may be less. All these considerations must be weighed. Or again it may be more

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profitable to construct an entirely new route. In America these things do not seem to be done by halves: but there are fewer difficulties in the way of putting through a railway project in any case, particularly if all the work is in one State.

As regards the contract work on a widening, it seems to be usual to make the contractor responsible for avoiding any interruption to traffic, and if flagmen and signalling arrangements are necessary that he should pay for them, taking account in tendering. There was some idea of embodying a penalty clause in the standard contract form, but it was abandoned as it was found that it would mean bigger quotations to cover possibilities.

In the case of electric inter-urban lines, it is remarked incidentally that a service of 30-minute trains with passing places at 15-minute intervals is as much as can be worked, and nearer passing places are not reckoned feasible. This sounds not much of a service, but apparently most of the trains are high speed and few stop.

C. E. VICKERS.

JOURNAL OF THE R.U.S. INSTITUTION.

September, 1905.

THE COMFORT OF TROOPS ON ACTIVE SERVICE, a lecture delivered by Capt. E. D. Swinton, R.E., deserves study by all soldiers. There are two ways of dealing with the problem:—"To lessen the inevitable hardships and discomforts of war upon the soldier by hardening him beforehand, and so training him that he will not feel them"; and to take the soldier as he is, and do the best to "temper the wind to the shorn lamb." The author considers it from the second standpoint.

He commences by saying—"The main object of an army in war is to beat the enemy in battle. To effect this a concentration of superior force at the right time and in the right place is necessary. To assist in this object, it should be the endeavour of each individual to do his utmost to ensure in every possible way the efficiency of the fighting machine, in that its numbers should be maintained and its physical, mental, and moral state kept as high as possible. The strategy and tactics of a campaign may be admirably conceived and carried out, and yet the whole operations miscarry if these desired conditions are wanting. The army may be brought to the right place at the proper moment, but may fail in its enterprise, owing to reduced numbers, poor physical condition, and the bad *moral* which often results."

Munson is quoted as showing that, 'as a general rule, in protracted wars armies suffer much less from wounds and deaths incurred in action than from disease; a fact which conclusively shows the necessity for a proper military knowledge of hygiene.' Also that wars are becoming shorter, and with improvement in the effectiveness of arms the proportion of casualties is increased; so that there is a tendency to an approximation

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of the rates from wounds and disease. A tabular statement shows the comparative losses in 12 campaigns since 1800, varying from 25 (disease) to 1 (casualties) among the Allied Forces in the Crimea to 3 to 1 amongst the British in the recent Anglo-Boer conflict and 1 to 1 for Oku's army during 9½ months of the war just concluded.

The diseases observed during continued warfare are chiefly produced by atmospheric exposure, exhalations from the soil, evil condition of latrines, and poor food; some of these, moreover, lead to excessive fatigue and consequent bad *moral*, which themselves are predisposing factors. The two principal diseases are enteric and dysentery.

Capt. Swinton divides the advice that follows into four main heads:—I. Sanitation and Hygiene (Water supply, conservancy, clothes and equipment, marches and fatigue); II. Shelter (Bivouac, tents, huts, entrenchments); III. Food Supply (Rations, fresh meat, cooking, requisitioning, supplementary rations); IV. *Moral*.

Under water supply a useful warning is given that the area round a well which must be guarded from contamination is a circle with a radius *at least* four times the depth of the well, the exact extent depending on the geological formation. As regards conservancy, the experience of Colonel G. H. Sim, R.E., is quoted—'The favourite food of the hot weather fly seems to be human excreta; and next to that, almost every article of human consumption, whether cooked or uncooked, especially milk, sugar, jam, meat, bread and butter.' Everything therefore depends on keeping the excreta covered and all articles of food protected. Sir Frederick Treves, in his *Behind the Lantern*, draws attention to the time expended by the Japanese medical officers in *preventing* disease in comparison with the time spent in *curing* it. Under the subhead for clothing an interesting list is given of the articles issued to the British and Indian troops and followers for the Thibet Expedition. In reference to fatigue it is well pointed out that men are more easily tired out by lack of sleep than by physical exertion, so that every effort compatible with safety should be made to let men have sleep.

In dealing with shelter, the author gives another useful warning against excavating inside tents or shelters in a malarious country or where wet weather is probable, since freshly disturbed earth is likely to produce fever. He recommends a cruciform trench as the most comfortable and easily defended pattern for a small picquet, this shape also requiring less material for roofing than a circular or square post. Proper stress is laid on the necessity for surface drainage.

As to food supply, it is said that meat should be cut up and issued to units *before* starting on a march, in order to save time and worry at the end. Men prefer messing in small squads. *Every man* should be taught how to cook the *rations he is likely to get on service.*

On the subject of *moral* one great secret of keeping troops in good mental condition is to interest them by explaining operations and by giving them reasons for orders.

The lecture concludes with some Odds and Ends, or tips, such as how to make a saltcellar, candlestick, and shade out of a bottle.

A. T. MOORE.

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RAILWAY GAZETTE.

August 18th, 1905.

SUPPORTED RAIL JOINT.—The N.E.R. are trying a supported joint for bull-headed rails. Sections of old 82-lb. rail on their sides bridge across under the foot of the 90-lb. rail, between two special chairs, one end of this piece of supporting rail being bent down to prevent creeping. As it happens, the foot of the 90-lb. rail exactly fits the hollow of the 82-lb. rail.

September 1st, 1905.

A GERMAN IMPRESSION OF BRITISH RAILWAYS.—By Herr W. Cauer, Railway Engineer and Professor, University of Berlin.—It is always interesting to hear a candid account of ourselves as others see us, and Herr Cauer's remarks are worth reading, though he recognises that comparison with German lines affords no absolute criticism owing to the difference in local conditions. Primarily, the German Railways are State owned or State controlled. The facilities to the public are therefore not so good, and the management is directed to "equalizing commercial fluctuations, promotion of industrial and agricultural activity (*i.e.*, a protective *rôle*), and, last but not least, the production of a surplus for the national treasury."

What first impresses the foreigner is the magnitude of our passenger traffic, and particularly the facilities afforded to suburban residents. It may be not out of place to remark that short distance suburban traffic, though it has got to be handled, does not pay so magnificently at all.

As to through traffic, Herr Cauer cannot have been very lucky, for he seems to have been impressed with the necessity for changing trains to get to certain minor places, and says English people do not seem to mind having to change. Now I should think that, compared with the Continent, through carriages were very numerous in this country. Of course long distance international trains have no place Time-tables, especially Bradshaw, strike the stranger as difficult, particularly as regards the distinction between a.m. and p.m. figures.

He remarks that the greater use of terminal stations and of stations in the centre of towns in England is doubtless due to greater competition. According to what he says, luggage, etc., is generally handled on the Continent at special platforms, which "simplifies the movements within the station," *i.e.*, keeps the platforms more clear; but of course the separate handling of luggage and the fact that cabs do not come into the stations makes getting away at the end of the journey more difficult.

The English employé is on the average more intelligent and more trusted than the German, whose organization follows military lines, as indeed the employés are ex-soldiers. The signalling arrangements are perhaps operated under more rigid rules there, and their mechanism is certainly more complex, because the man is trusted less. Signals are always worked by two wires, the counterweight is not relied on solely for returning the arm to the Danger position.

For all that, the arrangement of signals in Germany is generally simpler, because fewer are made to suffice: as a matter of fact English

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practice differs greatly on different lines, some of which make a much smaller number of signals suffice than others. He says that in some stations here the complexity of the signals is very great—"home, distant, starting, advanced starting, shunting, backing, siding, calling-on, dwarf and disc signals—some of which are practically the same"—yet by night there is no difference between home and distant signals.

In Germany it is considered sufficient to interlock signals and switches, but in England switches are locked with switches. This is a dark saying, for one does not see how interlocking can be perfect unless it provides against conflicting roads being set, and setting a road is always a preliminary to lowering the signal which controls it.

As usual the arrangements for handling goods traffic impress the foreigner, mainly from the fact that expeditious despatch has to be ensured: but I must confess that it is a surprise to hear him say ". . . the geographical simplicity . . . makes it possible to send more through cars." Surely the difficulty in England is to make up through loads!

Although shunting and marshalling yards are not so large here, because the number of routes to be sorted for is not so great, he compliments us on our arrangements, especially the show sidings like Edge Hill, Aintree, and Shildon.

The handiness with which trucks could be handled by the lever brake, as compared with the screw brake, gives him cause for comment.

September 8th and September 15th, 1905.

Each of these numbers contains a letter from a correspondent in China on the present condition of new lines constructing in that country.

C. E. VICKERS.

REVUE D'HISTOIRE.

September, 1905.

OUR EARLIEST INSTRUCTIONS FOR FIELD SERVICE.—These were drawn up in 1732 by Bombelles, and were tested in camps of exercise. They formed the basis of the instructions afterwards issued by authority. They are here printed for the first time (122 articles) with the notes and corrections of Belle-Isle and of the author.

TABLES OF THE FRENCH ARMIES DURING THE WARS OF THE REVOLUTION.—These were compiled about 60 years ago at the Ministry of War, but are now printed for the first time. They extend over 10 years (1792—1801), and show when the several armies were formed, broken up, or combined, what was their territorial area, and who commanded them. They do not show their strength or composition; but nevertheless they will be useful to every student of the wars of the Revolution.

THE CAMPAIGN OF 1797 ON THE RHINE.—The condition of Moreau's army as regards pay, provisions, and clothing is examined in detail, as Moreau attributed his delay in taking the field to his deficiencies under these heads.

E. M. LLOYD.

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CORRESPONDENCE.

SUBMARINE MINING.

SIR,

Submarine miners past and present will, I am sure, feel very gratified on seeing Sir Richard Harrison's letter in the *R.E. Journal* of September. It would certainly seem a pity if the work of such a large section of the Corps, now on the point of abolition, should remain unrecorded except in the archives of the War Office. Besides, there is much to chronicle not contained in official reports or in bare figure records, if a true picture of the Submarine Miners is to be presented.

Every day's delay will render such a work more difficult, because, with the passing away of the actors, there will be no opportunities of collating the necessary information.

It does not seem to me possible in the limits of an article to do justice to the subject. Perhaps a series of articles, published in sequence, might cover the necessary ground. But a book giving a "History of the British Submarine Miners" would appear to me to be the thing required. It is hoped that someone who has been in close touch with Submarine Mining may find time to produce such a work; and if one does, he can, I am sure, count on the thanks of all who were at any time engaged in that branch of the Corps and on their assistance in supplying information about the many points that may arise.

No suggestion has ever been more appropriately made than that of Sir Richard Harrison; and I hope that it will have the result which he intended.

Yours faithfully,

W. M. HODDER,

Lieut.-Colonel.

The Editor, "R.E. Journal."

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RECENT PUBLICATIONS.

Port Arthur: A Monster Heroism, by R. Barry. (8vo. New York).

From the Yalu to Port Arthur, by O. E. Wood. (8 × 5½. 7s. 6d. Kegan Paul).

The Battle of Wavre and Grouchy's Retreat, by W. Hyde Kelly, R.E. (9 × 6. 8s. Murray).

Moscow: A Story of the French Invasion of 1812, by Fred Whishaw. (6s. Longmans, Green).

Story of the Campaigns in the Peninsula, from July, 1808, to end of 1810, by Lieut.-Colonel H. M. E. Brunker. (7½ × 5. 7s. 6d. Forster, Groom).

Guide to Military History for Military Examinations. Part 1, Peninsula War, 1808–10. By Capt. G. P. A. Phillips. (7 × 5. 3s. Gale & Polden).

Die Angriffe der drei Barkiden auf Italien. Drei quellen-kritisch-kriegsgeschichtliche untersuchungen, von Konrad Lehmann. (10 mks. Teubner, Leipzig).

Guerres Contemporaines de la France et de l'Étranger, et Expansion Coloniale Européenne, 1792—1901, by Paul Charbonnet. (Folio. Paris).

The Decline and Fall of the British Empire: A brief account of those causes which resulted in the destruction of our late Ally, with a comparison between the British and Roman empires. Appointed for use in the National Schools of Japan, Tokio, 2005. (12mo. pamphlet. Oxford).

Les Armées et les Flottes Militaires de tous les États du Monde: Composition et répartition en 1905. (8vo. 1 fr. Berger-Levrault, Paris).

Taktische Unterrichtsbriefe, von Oberst Griepenkerl. 6te auflage. (8vo. Berlin).

Taschenbuch zum Gebranche bei taktischen Ausarbeitungen, Kriegspielen, taktischen Übungsritten, Manövern und im Felde, von Gen.-Maj. Franz Rohr. 17te auflage. (12mo. Vien).

Engineer Field Manual: Part 1, Reconnaissance, 1905; Part 2, Bridges, 1904; Part 3, Roads, 1905. Professional Papers of the Corps of Engineers, No. 29. (12mo. Washington).

The Duties of the General Staff, by the late General Bronsart von Schellendorff, revised by Major Bronsart von Schellendorff, Great General Staff. Translated for the General Staff, War Office, by Major H. A. Bethell, R.F.A., Major J. H. V. Crowe, R.F.A., and Bt. Major F. B. Maurice, Sherwood Foresters. (8½ × 5½. 5s. Wyman & Sons).

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Military Hygiene, by Lieut.-Colonel R. Caldwell, R.A.M.C. (10s. 6d. Ballière).

Nelson and the Twentieth Century, by Arnold White and E. H. Moorhouse. ($7\frac{1}{2} \times 5$. 5s. Cassell).

The Life of General Sir Andrew Clarke, by Colonel R. H. Vetch, C.B. ($9 \times 5\frac{1}{2}$. 15s. John Murray).

Text-book of Topographical and Geographical Surveying, by Major C. F. Close, C.M.G., R.E. ($10\frac{1}{2} \times 7$. 3s. 6d. Wyman & Sons).

Instruction in Photography, by Sir W. de W. Abney, K.C.B. 11th edition. ($7\frac{1}{2} \times 5$. 7s. 6d. Iliffe & Sons).

Cement and Concrete, by L. C. Sabin. ($9\frac{1}{2} \times 5\frac{1}{2}$. 21s. Constable).

A Treatise on Concrete, Plain and Reinforced, by F. W. Taylor and S. E. Thompson. (Chapman & Hall).

The Voyage of the "Discovery," by Capt. R. F. Scott, C.V.O., R.N. 2 vols. ($10 \times 6\frac{1}{2}$. 42s. Smith, Elder).

Great Japan: A Study of National Efficiency, by Alfred Stead, with a foreword by the Earl of Rosebery, K.G. (9×6. 10s. 6d. Lane).

The Risen Sun, by Baron Suyetmatsu. (9×6. 12s. 6d. Constable).

The Central Tian-Shan Mountains, 1902—1903, by Dr. Gottfried Merzbacher. Published under the authority of the R.G.S. (9×6. 12s. Murray).

Egypt, Burma, and British Malaysia, by W. E. Curtis. (9×6. 7s. 6d. Revel).

Cars and How to Drive them. Edited by Hon. J. Scott-Montagu, M.P. 2 vols. (7s. *The Car, Illustrated*).

Wild-Fowl, by L. H. de Visme Shaw, W. H. Pope, and A. Innes Shand. (5s. Longmans, Green).

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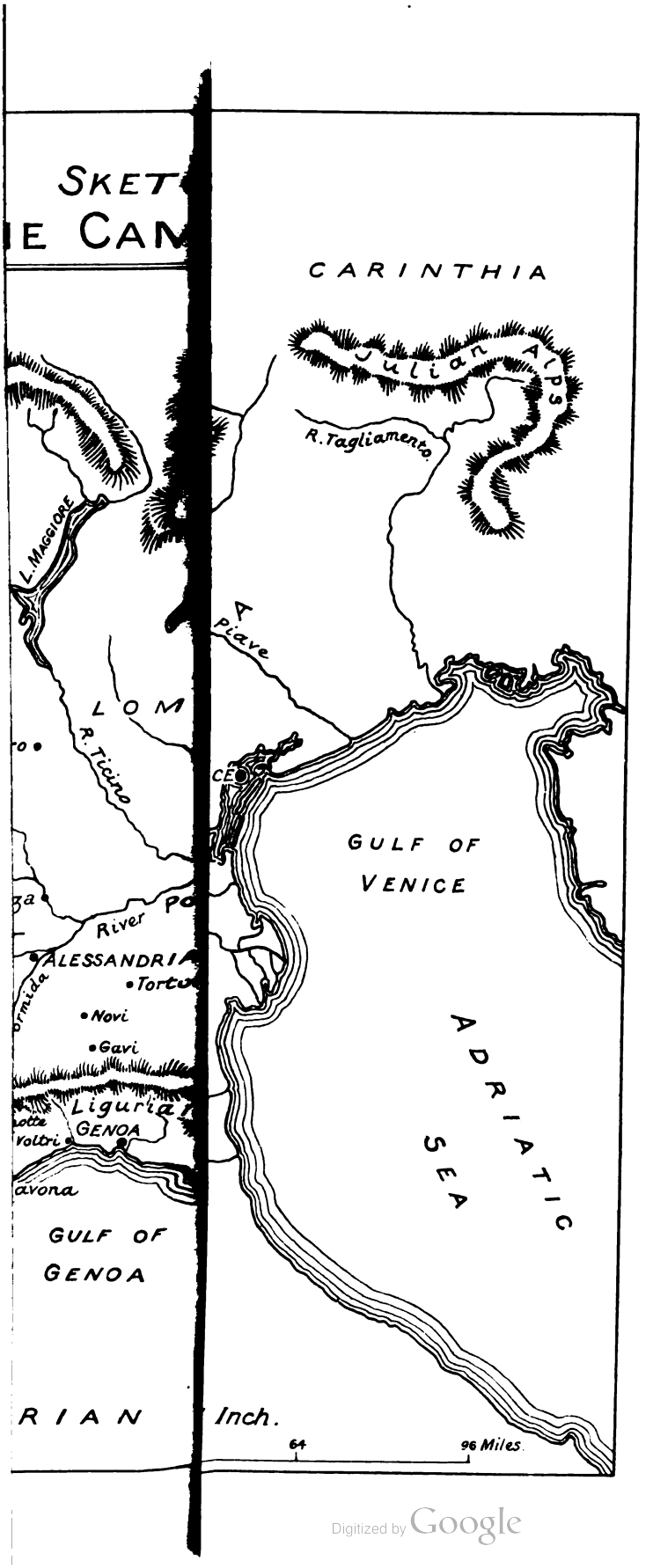

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Militia Literary: G. V. C. Irwin, A. St. J. Wright, M. C. Coote, R. Lechmere.

Woolwich (Dec., 1904): 2nd, F. W. Thicknesse; 7th, O. E. Fane; 24th, C. O'Driscoll Preston. (Two others previously).

Sandhurst (Dec., 1904): 24th, G. de la Poer Beresford; 32nd, H. G. C. Colville; 68th, C. H. Blackburn. (Two others previously).

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G. C. SLACKE. Passed out of Sandhurst. Corporal, Rugby XV. Indian Army.
H. MULLALY. Passed out of Sandhurst. First Prize in Gymnastics. Indian Army.
J. WATSON. Passed out of Woolwich. Obtaining Royal Engineers. Corporal.
C. MULLALY. Passed out of Sandhurst. Corporal, Rugby XV. Indian Army.

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March, 1905. **L. J. GRANT, Sec. Sen. Acad.**

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THE FUTURE OF THE ROYAL ENGINEERS.

By MAJOR A. T. MOORE, R.E.

A DIRECT invitation to contribute to these columns on the subject of the training and organization of the Royal Engineers has resulted in a mild epidemic of *cacoëthes scribendi*, which is evidence of the healthiness of our corporate body and augurs well for the vitality of its principal organ. This outbreak has doubtless been occasioned by the knowledge that a private Committee had been appointed by the War Office to consider the future of the Corps; and the development of the literary scarlet fever may possibly assist in the diagnosing of the disease from which the Corps is suffering—or, rather, supposed to be suffering—and for which the Committee is no doubt expected to find a cure. I say supposed disease because, as a point of fact, the body of the Corps is in excellent health; it only requires some new clothes, a few modern patterns of headgear, and some suitable campaigning boots.

The correspondence having progressed thus far, it may be found useful to recapitulate and amplify some of the main arguments which have been submitted by other writers and add a few further considerations.

IMPRUDENCE OF IMITATING CONTINENTAL MODELS.

First and foremost, change for the sake of change is mischievous. It is unsound to attempt to organize our small British Army on the model of the huge systems on the Continent. The conditions of the recruiting and foreign service of our Army are totally different to those of any other; our forces are liable to serve in peace and war in every part of the globe, from the deserts of Northern Africa to the glaciers of the Himalayas, under climatic, physical, and other circumstances many of which cannot be foreseen. Hence we must proceed on independent lines.

To begin with we must have a greater proportion of engineers than in other armies; these engineers must be artisans, and the majority must be "handy men." There appears to be a school of thought that considers it advisable for our engineers to be modelled on the water-tight compartment system of the German Army. On the other hand, curiously enough, one hears, on equally good authority, that the Germans, having found by recent extra-European experiences that their water-tight compartment system is unsuitable, are seriously thinking of transforming their field engineers (pioneers) into handy men like ours.

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WAR ORGANIZATION THE FIRST REQUIREMENT.

Military engineers must be organized and trained for war. We are soldiers first and engineers afterwards, but only to the extent that our peace employment on civil engineer work must be limited to what is useful training for us for the diverse war purposes of the British Army; in other words we are soldiers as well as engineers. Once these elementary facts have been acknowledged the rest will be comparatively plain sailing. Having established a proper War organization we must adhere to it in Peace. In peace every officer and man must first of all be trained for war; when this training has been effected, the personnel can be employed in the manner that will be most economical to the state.

SPECIALIZATION AND DISMEMBERMENT.

Specialization and decentralization are in themselves most desirable virtues. But like other good things they may be carried to extremes. When applied everywhere and for everything, regardless of corollary circumstances, they tend to duplication of staffs and to other extravagances. An absolute specialist is not so useful a person, at any rate in the Army, as one who, in addition to his expert knowledge, possesses some acquaintance with other trades.

Our personnel, certainly our officers, should be 'Jacks of all trades and masters of one,' in addition of course to that one trade, the 'field engineer,' which constitutes our primary right to exist. Every individual, having mastered field engineering, should learn the elements of the various other duties which the Corps is called upon to perform on active service; and he should then definitely take up one of these other duties as a speciality—*e.g.* Machinery, Telegraphs, Ballooning, Railways, Search Lights, Survey—, on which he might always be employed when there is a vacancy for him in that particular branch. When not so engaged he should be utilized in one of the two normal employments of the Corps, that is either with a non-special (*e.g.* field engineer or fortress) unit or on constructional engineering (see below).

The same universality may not perhaps be so desirable for the rank and file, nor possible in the case of short service enlistment. But for officers it is distinctly advantageous; and our so-called specialists have over and over again proved the merits of our versatility by showing conspicuous talent as field engineers on finding themselves in tight places.

Specialization, moreover, may lead to dismemberment of the Corps, though there is no valid reason why this should follow. We have enough branches in the Army as it is; we must have 'the three arms,' their transport, provision, and pay services, their ammunition and matériel supplies, their medical and veterinary aids; but there is

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no ground for assuming that the Royal Engineers cannot carry out all the other technical work required.

It must be remembered also that, if the Corps is permanently divided up into separate compartments, *each* compartment must be sufficiently strong for all its probable tasks ; hence the total establishment must be largely increased. Under the 'handy man' system, however, any non-special unit can assist another of a separate branch, or even be converted to other uses, as Fortress Companies were for Railway construction in the South African War.

Even if the engineer units are to be specialized, there is no reason why they should not all remain Royal Engineers under one expansive organization, just as transport and supply are included in the Army Service Corps, and medicine and surgery in the Medical branch, and as Horse, Field, and Garrison gunners are still Royal Artillery.

We may now proceed to consider details, but in general terms only. Readers will kindly attribute any semblance of dogmatism to the writer's desire for brevity.

STRENGTH AND ORGANIZATION.

The war strength of the various units comprised under the generic title of Royal Engineers must be based on the above-mentioned axiom that we must have a larger proportion of technical troops than is usual with other armies. At present the proportion is less.

It seems to be generally conceded that there should be one Field Company (with water supply, map reproduction, and telephone repair equipment) to each Infantry Brigade and one Field Troop (with similar equipment) to each Cavalry Brigade ; and a Bridging Company, a Balloon Company, and a Telegraph Company to each Infantry Division. The number of Railway and Reconnaissance (or Survey) units cannot be laid down with similar confidence based on experience of our normal war requirements ; but the maximum likely to be required should be maintained. There is even less experience to work on with respect to Field Search Lights ; the recent war in the Far East has brought to notice the necessity of a telephone organization (either separate or embodied in the combatant units) in the actual firing line ; and no doubt Wireless Telegraphy will also be established in the near future.

Over and above all the units mentioned, corresponding with the organization of the strictly combatant units of a Field Army, there must in our case be a considerable number of others for service in fortified posts at home and abroad. These "Fortress Companies" now include the units of the defunct Submarine Mining service.

It appears to be unnecessary and undesirable to organize these units on the basis of a Field Army. The circumstances of the various 'places' are different, and each must be treated independently in the light of

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its particular objects and conditions. In some cases the units are required only for the purpose of local defence; in others there is a possibility of their employment as field units in a reinforcing contingent despatched to a theatre of war elsewhere.

It is a question well worth consideration whether the sections allotted to the operation of Fixed Search Lights should not be combined with the Fortress Artillery and the Naval Submarine (including Mining) establishment with a separate Coast Defence Corps under the Admiralty. The personnel of such a Corps might usefully be liable to service afloat, on the principle that in taking up a position for defence it is advisable to look at it from an enemy's point of view. If interchangeable with Naval personnel for the same duties, they might form a valuable reinforcement to the Navy. In any case this system would result in a much-to-be-desired unity of control in our defended ports.

In addition to the whole of the above, and equally necessary, there must be surplus staffs and personnel, chiefly officers, to carry out an unforeseen amount of work on Lines of Communication and for the military occupation of a conquered territory and also the hundred and one equally unforeseen jobs that crop up during such warlike operations as are usually the lot of the British Army. This surplus might be obtained from civil life when required; but the employment of civilians as a reserve for military engineers in war would cause much more dislocation in the engineering profession than the system of having surplus military engineers engaged in peace time on civil work. Moreover a civil reserve would be unreliable as to numbers, and necessarily less efficient than a military surplus trained for war.

One very important point with respect to organization is the necessity of engineers being represented on all Army Staffs, from that of the Army Commander to that of the Brigadier; this is essential in order that engineer work may be foreseen and properly co-ordinated with strategy and tactics. It is obvious that the engineer representatives must be of suitable rank.

FIELD COMPANIES *v.* PIONEERS.

It has been suggested in some quarter that our Field Companies might be reduced to the quality of Pioneers. But this would be a retrograde step, taking us back to the days of the Peninsula War, when our predecessors were criticized as being 'good zealous regimental officers, but not practical and scientific.' Our capabilities in the field are now of a much higher order; and this progress has been due to the fact that our men are artizans and our officers educated in the details of the building trades.

Instead of levelling us down to Pioneers, our aim should be to level the Infantry upwards to the point of rendering them capable of

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carrying out all the spade work of ordinary field fortification without assistance. The Field Companies, R.E., would then take their proper places as advisers and instructors in questions of field defence, their actual work conprising the artizans' share of fortification and also map reproduction, instrument repairing, water supply, and other duties of a technical nature.

EQUIPMENT.

Equipment is, for the present, a minor question. It can only be decided on the basis of actual war experience, and those who have the most experience of active service in any one branch of the Corps are the best qualified to decide for that branch.

The only details that it appears necessary to refer to here are :—

(1). The question of enabling field engineers to be carried on the march whenever there is work for them at the end. It is not advisable to have them mounted on horses, nor is it required that they should all be carried at one and the same time; but it is obvious that a man who has been carried over all or portion of a march will execute better work, and do it quicker, than one who has trudged it throughout.

(2). The possibility of reducing the number of patterns of R.E. technical vehicles (or, at any rate, of their parts) and tool boxes by standardization.

(3). The necessity of the horses and drivers of technical vehicles remaining an integral permanent portion of the technical unit, instead of, as in the German army, being provided by the Army Service Corps (Train).

EDUCATION OF OFFICERS.

The basis of our education must, for reasons given below, consist of a thorough grounding in constructional engineering. This might be preceded by a sufficiently long training in the 'art of war' (strategy, tactics, military history, law, and organization, etc.); and should be followed by an exhaustive course of field engineering proper and by elementary courses in the more special duties of the British military engineer. Having been set down on the main road to handiness, every officer should be encouraged (so far as the requirements of the service generally will permit) to deviate into one of the special branches and gain expert knowledge therein. As many as possible might, later on, be given a further practical training in construction by being attached to large engineering and contracting firms, in the same way as some now are to the great railway companies to learn traffic and locomotive details, but for longer periods.

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WAR TRAINING AND PEACE EMPLOYMENT.

As stated above the first consideration is training for war.

In the case of the really special units, that is those whose duties have nothing quite analogous in civil life,—*e.g.* Ballooning, Search Lights, Reconnaissance, and Wireless Telegraphy (possibly also ordinary Telegraphy)—this war training must embrace their whole employment in peace. This would apply also to special sections of Fortress Companies. It is this whole-hearted, continuous, one-purpose training that made the late Submarine Mining service one of the most efficient in the Army and is the cause of the competence of the Telegraph companies.

For the other units continuous war training is not essential. After carrying out annually a sufficiently comprehensive course of field engineering (whenever possible in conjunction with 'the three arms'), and in the case of Bridging and Railway companies a further or a partly alternative course in these subjects, they could be employed during peace on work that is reproductive to the State, *i.e.* on what may be termed public works. This is the best training to produce 'handy men.'

Such peace employment could be arranged, if once the general public recognized that war training is the first duty of the engineers as of other branches of the Army, and that any work done for the State during peace time after completion of the war training was a net gain to the State. At present the financial point of view appears to be that time spent on war training by the engineers is a net loss to the State; that the Royal Engineer, because he is better paid than other soldiers—as a matter of fact his pay is not very much higher than that of some other Corps—can only be tolerated so long as he justifies his pay by spending the greater part of his peace time on work that is not his best training for war. It is forgotten that this higher rate of pay is due to higher qualifications, as in every other walk of life. The Garrison gunner gets more pay than the Field gunner, because his scientific attainments are greater; similarly the Cavalryman receives more than the foot soldier; but no one expects all these, and others, who receive more wages than the unit representative—the Infantryman,—to spend a portion of their peace time, representing the difference between their wage and the unit wage, in recouping their extra cost by neglecting the work for which that extra cost was originally sanctioned.

The ultra-military school amongst civilians takes the opposite view that the Royal Engineer should do no work in peace that has not a direct counterpart in war.

As regards the commissioned ranks it might be possible to second officers for tours of service in the Board of Trade, Local Government Board, and Office of Works at home and in similar departments

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in the Colonies ; or to employ experienced ones as resident engineers on behalf of the State at all large works in course of construction out of State funds.

At the same time every opportunity should be taken during peace training and manœuvres of employing Royal Engineers in conjunction with the purely combatant arms. It is only by such mutual intercourse that the combatant arms can be taught to appreciate the value of engineers and to use them with proper effect, and, on the other hand, the engineers taught that their true *rôle* lies in proving that "Science is the Handmaiden of War." The personnel of Field Troops and Companies might well be distributed, during the squadron and company training of cavalry and infantry, amongst the units of the brigades to which they belong. The 'surplus' engineer officers, employed on civil engineering, could be kept in touch with war duties by being attached to staffs or to regular engineer units during combined manœuvres.

CONSTRUCTIONAL (OR CIVIL) ENGINEERING.

There remains the normal employment in peace of the personnel required in war surplus to the needs of the regular units. This surplus will consist mostly of officers ; these cannot be improvised when war breaks out, whereas subordinates of adequate capabilities probably could be found in sufficient numbers in the civil engineering profession.

The best training for this surplus, as well as for the non-special units in their spare time, is constructional engineering. In no better way is it possible to obtain that experience in the control of men, money, and materials which produces the judgment, self-reliance, resourcefulness, and adaptability to circumstances on which the reputation of the Corps has been established.

A sound knowledge of building construction and design, in practice and theory, is necessary for the proper understanding of a great deal of military engineering ; and such knowledge is especially required in us for the proper utilization of our men, who are artizans.

Fortification being a purely military subject, it is obvious that this work ought to be entrusted to military engineers.

Barrack construction and, possibly, maintenance might also be in their hands ; partly because a soldier is probably better qualified than a civilian to judge of the requirements of a soldier ; and partly because barracks are in many places closely associated with works of defence, and it is wasteful to have two separate organizations, working independently and possibly antagonistically as to prices, within the same small area. Lately we have seen barrack construction in the army—at home only at present—removed from the control of the Royal Engineers, and maintenance left in their charge. On the other hand, the Admiralty continues to place Royal Engineer officers

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in charge of the design and construction of naval barracks and works, but employs civilians to maintain them. It is the wide experience obtained in construction that we require, not the narrow monotony of maintenance; but whether the construction is to be of barracks or of purely civil works is immaterial.

Apart from barracks there is a wide field for the employment of our surplus officers on State works at home and in the Colonies; and every endeavour should be made to procure them such employment. In India, under an appreciative administration with a continuous policy, numbers are employed on Railways and Public Works; and the wisdom of this system has been exemplified time and again by the efficiency of such officers when called upon to carry out works on active service. When and if the restriction of our education and training at home renders us no longer fit for employment on such works, the Indian Government will presumably find it necessary either to afford us a further schooling on its own account or to depend largely on civil engineers for war purposes.

ADMINISTRATION.

The Headquarter Administration in peace must correspond with the Headquarter Staff in war. Hitherto the Corps has suffered in a militant sense in that its chief technical representative at the War Office, the Inspector-General of Fortifications, has perforce been compelled to devote most of his time to that portion of his duties which was most exposed to financial criticism, the administration of works. Hence active service needs have necessarily received less attention than they deserved.

We require at headquarters Directors of the various branches of the Corps which have a separate organization in war, viz.:—Chief Field Engineer, Director of Telegraphs, Director of Railways, and Director of Surveys, all with nucleus staffs. Each of these officials should be an expert in his branch; and each should be subordinate to that member of the Army Council who represents in peace the officer of the Headquarter Staff of an Army in the Field to whom he would be responsible in war.

This system of decentralization might be carried down to the local Commands, wherever there are sufficient troops (in war organization) to justify the procedure. But this is not essential; the main desideratum is to ensure our war requirements being kept in the foreground during peace by proper representation at headquarters.

We must also have an agent to control the enlistment of the men and the distribution of the personnel generally to the various branches. This official has at present no place with an Army in the Field; his duties in the field are now carried out by the Chief Engineer, who has sufficient work of his own to perform; he should have an equivalent in war.

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In addition to the above four Heads of Branches and Head Agent, there must of course be an official in the very important position of Director of Fortifications and Works, to supervise what has been aptly termed the 'surplus officer department.'

A useful adjunct to the whole—but independent of them all, and attached possibly to the Military Operations Division,—would be a properly organized and well-manned R.E. Intelligence Bureau. The duty of this Bureau would be to keep the Corps in general in touch with changes and progress in the technical troops of foreign armies by means of periodical bulletins; similar information might be afforded with reference to ourselves, for one half of us is now ignorant how the other half lives and what it does. Officers responsible for any work of exceptional interest within the purview of the five technical branches above-mentioned might well, on its completion, be placed temporarily on special duty to draw up a detailed report for the benefit of others and for permanent record. This procedure is followed with much advantage in India; elsewhere at present there must be a considerable waste of intellect through officers carrying out schemes *ab initio*, either because they are unaware that anything of the same description has been previously executed or because no details of such previous efforts are obtainable. The same practice of reporting would apply to the engineer work in all military operations, and to any particularly serviceable use of engineers on peace manœuvres. All information collected by the Bureau, which is deemed worthy of general dissemination, would be printed and issued at public expense; the comparatively small cost would be amply repaid.

We might even go a step further and place this Bureau under the officer occupying the Presidency of the R.E. Committee, who in this case would have to be absolved from all other duties. This same Committee might be reduced to three experts—electricity and machinery, field engineering, building construction—similarly devoting their whole time to the many intricate subjects that come under consideration.

THE CORPS AT THE BAR.

Ever since the institution of Constitutional Government it seems to have been the privilege of the spending departments of our naval and military forces to be called to the bar of public enquiry. At first sight it is difficult to see why civilian departments of State, most of which are spending in a greater degree, should have remained exempt. Possibly it is by reason of the ancient jealousy of a standing army on the part of the people; or because the militant departments alone have had their deficiencies exposed by the stern test of war; or because the taxpayers get a more visible and more personal result from the expenditure of other departments.

The Navy is now free from the strangling net of public apathy. The Nation has realized the need of a strong Navy as a purely

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economic question of national insurance; the Navy demands the money it requires, gets it, and spends it in its own way. Some day the public may further realize that a navy without an army is only half a weapon, and then the Army will come into its own.

The Corps of Royal Engineers, being most in evidence amongst the spending branches of the Army, though by no means the greatest spendthrift, has had its full share of enquiries. Omitting those of which the evidence taken and the consequent report have remained unpublished, it is safe to assert that they have all resulted in an endorsement of the merits of the Corps and an increase to its numerical strength. It often follows on enquiry that a servant of the public, much abused as extravagant and inefficient, is found to be in reality a conscientious, hard-working, sorely-tried individual, who does the best he can with the materials at his disposal and whose shortcomings are not of his own making but the result of restrictions imposed upon him by others.

That the Corps, nurtured on constructional engineering as the essence of its peace employment, has been a success in war is proved by its corporate and individual services in practically every campaign since the Royal Warrant for its establishment, and by the prowess of its ancestors in earlier times. That it has also been of benefit to the State in peace is evidenced by the numerous engineering works of importance which have been executed by it or under its supervision in all parts of the Empire, often when no other agency could have carried out the work at all. That it has been a good school for the highest branches of State employment might be proved by a mere recital of the names of the many eminent engineers and administrators whom it has produced; though many of these attained fame in extra-military employment, yet the fact of their having been brought up in the Corps has added to its prestige and has attracted others of similar calibre to take their places. The truth of these statements will be patent to anyone who reads our two latest biographies—*The Life and Times of Major-General Sir James Browne* and *The Life of Sir Andrew Clarke*.

CONCLUSION.

Some of the other contributors to these columns have hidden their identity under a pseudonym, on the very justifiable pretext that views expressed on such matters as the above should be considered on their own merits without reference to the rank or office of the writer.

Being debarred as editor from taking a similar course, I wish to state that I am in no sense behind the scenes as regards the terms of reference to the present War Office Committee and the decisions at which that Committee are likely to arrive. I have only entered the lists from motives of *esprit de corps* because I have served long enough to feel certain that either over-specialization on the one hand or over-militarilization on the other would be our ruin.

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THE ORGANISATION OF THE CORPS.

By 'SILEX.'

IN the November number of this *Journal* 'Nemo' gave us a most interesting article to ponder over. As the Yankee would say, he gets down to business: this is what we want.

The science of Preparation for war has been shown us by the Japanese to be

(1) What the late Lord Salisbury called "the intelligent appreciation of events *before* they occur" and

(2) the businesslike preparation to meet these events: viz., by examining localities, drawing up lists of probable works, with the detail of staff, materials, and training required for execution.

Lord Lansdowne recently made the epoch-making statement that in future the foreign policy of the nation must be definite instead of nebulous; that it must be a policy of embodied principles, of objects with alliances to further them, instead of the old drifting or negative state of "glorious isolation." The Liberal Party, and public opinion generally, may be said to have confirmed this conclusion already.

This change in the political ideal is of first importance to the army. It promises that policy will be more definite, and that, therefore, military preparation will be possible in more decided directions as to likely wars. The work of the Defence Committee has, doubtless, done much to educate our statesmen to this conclusion, and the army may find itself called upon to emulate the Japanese in practical preparation. If so, in no field of activity will more be required than in that entrusted to the Corps of Royal Engineers. It is, therefore, essential that we should put our house in order and be ready to comply with coming demands.

1. WAR REQUIREMENTS.

'Nemo' gives us a clear division of R.E. war duties, viz.:—

(1) Duties of R.E. Field Units working in conjunction with the field army—

(*a*) Duties foreseen and specially organised: field works, bridging, etc.

(*b*) Handy-man duties, trade skill works.

(2) Duties for Special Services behind the field army: to assist, or free the field units to advance—

Administration of Districts, base works, lines of communications, etc.

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The whole of these 'Nemo' places under the Chief Field Engineer of the General Staff; because all energies must be directed to one end—the defeat of the enemy in the field. We may accept this as the best arrangement for war.

2. PEACE PREPARATION.

Following the above we require :—

(1) An organisation to study probable campaigns, and work out what will be required from
  (*a*) R.E. units, (*b*) Special services.
(2) An organisation to guide R.E. training and employment in peace to meet these probable duties in war.

'Nemo' invents the term "Surplus Department" to cover the activities of R.E. officers and staff not in Field units. This term, as he will probably admit, is likely to mislead. In no sense are such duties *surplus* in war. They are essential. A better designation—and we want one—would be "Special Service Department."

3. PEACE ORGANISATION.

Here the writer must part company from 'Nemo,' who gives us in peace a Special Service Department too much divorced from Field units. He places the former under the Master-General of Ordnance; the latter under the Chief of the General Staff. Instead of this we require an organisation that will be practicable, that will work these branches together as far as possible, as in war; and which will bring both under the direction of the authority which studies war requirements. 'Nemo' will probably assent to this as desirable, provided the old trouble he mentions is guarded against, viz., the undue subordination of training in war requirements to the meeting of peace exigencies. The sole object of C.R.E.'s must not be to *get works done*, with the R.E. *anywhere* in the scheme; but to adjust the works so as to *train the R.E.* This can only be done with the consent of and proper organisation at the War Office.

Leaving the Railways under the Q.M.G., where they belong, the following is suggested as the War Office grouping :—

Chief Engineer of the General Staff.
1. Director of Field Engineering.
2. Director of Telegraphs.
3. Director of Surveys.
4. Director of Special Services.
  (*a*). Fortifications.
  (*b*). Other Military Works.
  (*c*). Civil employments.
5. Director of Engineering Intelligence.

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The above might be under the Chief of the General Staff, though it would be more just to the Corps if the Chief Engineer were himself on the Army Council, and better for that body too.

The great point is that the 5 headings given above require to be co-ordinated under a Chief Engineer because they must largely act together in peace, and can assist each other in training for war. A few remarks as to the functions of branch 5 will make this clearer.

DEPARTMENT OF DIRECTOR OF ENGINEERING INTELLIGENCE.

1. *Training Section.*—Receives and compares the reports of training and works of the Corps; and under the direction of the Directors 1 to 4 circulates all useful information. Also keeps in touch with the Railway Branch, with R.E. Committee, and School of Military Engineering.

Example.—A special service officer is employed on bridges, and reports on useful devices for repairing iron girders in war. Report passed to Director 1, who decides to circulate it to Bridging Companies. R.E. Committee asked to provide for experiments.

2. *Intelligence Branch.*—Collection of engineering information for possible war operations. These would be designated by the War Office Intelligence Department.

(*a*). Ports and Landing-places abroad are indicated. Information collected as to local supply of materials, best way of importing stores, prices and markets. Existing piers, stores, water supply, etc., and estimate of additions likely to be required.

(*b*). Other Works up country. Likely centres for hospitals, etc., and information as above.

(*c*). Probable Special Service Staff for various campaigns, and arrangements to mobilise.

(*d*). Intelligence affecting Field units *re* waterways, bridges, roads, soil for fieldworks, woods, local tools and materials, etc., in various countries.

The utility of a Chief Engineer would be assured by his being continually reminded of the requirements of war by review of this intelligence work, for he would see what would probably be wanted from the Corps in war. He would then take good care that the training and employment of Units met this, and would hold the balance between the exponents of what an Engineer soldier should *look* like and what he should *be*. He would direct and support the Chief Engineers of Commands in this matter of training. They would consult with their C.R.E.'s as to each year's programme of work for

(i.) Field unit duties.

(ii.) Special service duties and works for trade skill.

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In conjunction with the Staff this programme could be drafted. For such periods as could be arranged the branches of the Corps would be brought together as far as possible. It is surely unsound to divorce them altogether. In practice we have to provide for the many stations where R.E. units *must* perform all-round functions, and the work be evenly distributed. Even if practicable, separation would not be good. A Special Service Department whose junior personnel was exempt from military duties would tend to become civilian and to forget the war service reason of its existence; whilst Field Units, cut off from works, would tend to degenerate into pioneers.

FIELD UNITS' TRAINING.

We must sympathise with the desire to shine on peace manœuvres. It is essential that the Corps should work with other arms in peace, and very good for those other arms as well. But we cannot afford to overdo it. Manœuvres offer little opportunity as a rule for trade skill—for what the Sapper mostly does in war. In a few years the Cavalry and Infantry will lean very little upon us in the matter of Field engineering. We can improve our methods and the following suggestions, often mentioned, seem worthy of attention.

1. Annual field works to be carried out on manœuvres with other arms.
2. Where this is not possible, the programme of work to be based on a tactical scheme, *i.e.* siting, etc., for a definite use.
3. Evolution of fieldwork drills to replace most infantry drill for all R.E. but recruits. Examples:—

   (*a*). Given a tactical scheme. Extending over a position and laying out works, distributing stores, measuring and estimating clearings, obstacles etc.; calculating for Infantry parties and their control.

   (*b*). Given sketch of a standing camp. Laying out blocks, running out a water supply of galvanised piping (any sapper can be taught to do this).

Such drills would be more interesting to an inspecting General than a feeble infantry repertoire, though they would be done with few words of command after telling off. Their great utility would be the demonstration that the smart bracing moral action of drill can be imported into such work of useful nature. The idea requires to be dissipated that the motions of trade skill must be of the slack and sloppy order.

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SPECIAL SERVICES.

1. Officers on special civil employments of a nature useful for war. These might be open to officers who have passed for promotion to Captain, and who have qualified in the training described later as "Superintendence." It is of very doubtful utility to send young officers through special courses before this.
2. Works connected with the army, such as Fortifications and Barracks. It is here that every officer should acquire the knowledge by *practice* of Superintendence. It is the kind of engineering essential for war, and should guide
   (*a*) The general education in construction at the S.M.E.
   (*b*) The conditions of R.E. employment on works.

If the Reader will now cast his eye over Appendices I. and II., he will see what is meant by Superintendence. He may gather that these statements attempt to provide for war exigencies, for they are, in fact, based on experience of large works during and after the war in South Africa. R.E. officers were then called upon to display their general engineering skill, organising powers, and business experience as to civil methods and market resources, often to the extent of a monthly detailed expenditure of £10,000. There was no War Office scheme, there were no detailed plans of sites, etc., no detailed estimates, and no large contractors to do the work. This is the situation to be expected in war, and for which we should be trained.

It may be said that most of the training indicated could have been obtained in peace under the normal system of Division work at home. To this it must be replied that in practice it never has been. It is time to look facts in the face; to consider, not what officers *should* do, but rather what they have done, and are likely to do. The first lesson of statesmanship is to take account of human nature as it exists in the sinful state, and not to legislate for a community of angels. We may ascribe to original sin what is deplorable in the following statements:—

(1). Intelligent officers will not display keenness in unintelligent work. Such is the duty of watching contractors execute the designs and estimates of other people, when without authority to do anything.

(2). They will learn little as to organising works and business methods if a contractor does it all.

(3). They will learn little about market prices and types of stores if they never have to select stores because War Office contracts, etc., allow no latitude.

(4). They will learn little as to economy of labour if they do not make small contracts themselves and watch R.E. and civilians on piecework.

(5). Summary—no power, no interest: no interest, no efficiency.

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The above ideas are not new, but are merely a statement of what has often been said in excuse for the full-blooded and vigorous who neglect their "bricks and mortar." There is no reason to take up a hopeless attitude, to say that works at home *cannot* be made instructive and so we had better do without them. Such are the counsels of Despair. The enlightened policy of "applied knowledge" is being pushed in the training of most branches of the army, and in promotion examinations. The great results already attained have astonished everyone. It may, therefore, be taken for granted that any well-thought-out scheme facilitating similar training in *applied* engineering on works for the officers and men of the Corps would have the approval and support of the highest authorities at the War Office, and the sympathetic concurrence of our civil masters in addition. No one will deny that the Engineer with only theoretical knowledge is about as much use to the army in war as the book tactician.

"Nemo" does not say definitely that the Field Units should not be employed during peace on works, where Superintendence can be learnt by the Officers and the raw artisan youths enlisted attain skill and experience at their trades. But his scheme makes no adequate provision for such training. He appears content to secure a pioneer training only for the men, whilst the Officers get what engineer training they can by circulating through the "surplus" department. Are the units to be employed on works at all; and if so, where is the controlling authority to adjust the rival claims at stations of pioneer and engineer training? These claims have to be adjusted, and it appears that the trouble has hitherto been that we have lacked a good organisation at Headquarters to make this adjustment, to study the requirements of each, and provide what is necessary to meet them. Hence, we find the advocates of pioneering discontented, alleging that field duties are sacrificed to Works; whilst the champions of engineering grumble that Works are not organised in a way to develop the engineering qualities demanded in war. The present writer believes that both requirements can be met in the manner he has indicated; and that the *rôle* of engineer is the more important, since it includes that of the pioneer. Moreover, the rapid advance of other branches of the army warns us to raise our centre of gravity in the scientific scale, not to lower it towards the pioneering *rôle*.

The ideal we have inherited is not that of a Pioneer Corps but of an Engineer Corps, with an historic roll of achievement too long to be inscribed upon any single banner. It is, surely, not for us to resolve this noble inheritance of unlimited boundary into the walled enclosures of a group of pioneer bodies with their soul-less programmes of occasional effectiveness. If prone to do so, let us honestly own that we be pigmies who find the shoes of the giants before us too large for our diminished proportions. For, when such a catastrophe overtakes us we may truly say "Ichabod"—the glory has departed.

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APPENDIX I.

SCHEME OF TRAINING.—OFFICERS.

GROUP I. OBLIGATORY.

A. Subjects now required for promotion.
B. S.M.E. Courses.
C. Superintendence—(*a*). Theoretical—S.M.E.
(*b*). Practical—3 years on works. (In or attached to Field Units).

GROUP II. SPECIAL.

1. Works, including Fortifications.
2. Water Supply and Drainage, including pumps, septic tanks, etc.
3. Electric machinery, motors, search-lights, lighting, etc.
4. Steam machinery.
5. Railways and Roads.
6. Telegraphs.
7. Bridges.
8. Surveys and Map reproduction.

REMARKS.

(i.). No officer to take up Group II. until passed as efficient in Superintendence.

(ii.). Officers then to submit to Group II., being given their choice of subjects as far as possible.

(iii.). After reasonable opportunity of becoming "Master of one" subject in Group II., officers to be encouraged to keep up their qualifications as "Jack of all trades," especially in 1, 2 and 7.

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APPENDIX II.

SUPERINTENDENCE.—PART I. THEORETICAL.

1. OFFICE WORK.

1. Clerking:—Registration and correspondence; dealing with other departments and staff; general survey of books of Regulations; hints on practical points.
2. Finance:—Powers in, and methods of procedure.
3. Draftsman's Office:—Records; distribution of work; sun printing.
4. Approximate Estimates; Tables on the "square" system for each trade.
5. Business:—Home market for supply of materials; catalogues; leading firms; prices and discounts; trade newspapers; conditions of delivery and acceptance.

2. ORGANISING FOR PROJECTED WORKS.

1. Hints on sites; preliminaries to consider as to lands, water rights, drainage disposal, etc.; site plans.
2. Staff to be collected, and what duties to be clearly laid down; office requirements.
3. Hints on collection of materials; arrangement of stores and yards; police and fire precautions.
4. Workshops; hints on small plants and labour saving machines types and cost.
5. Management of transport on works.
6. Labour camps and sanitation.

3. EXECUTION.

1. System of laying out details and verifying sites.
2. Storekeeping and upkeep of stores; sawmill regulations.
3. Distribution of work; methods of supervision.
4. Hints on daywork, on piecework, and small contracts.
5. Tricks of various trades as to materials and labour.
6. Infantry working parties, organization and payment.

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SUPERINTENDENCE.—PART II. PRACTICAL.

1. Office Work.

Officers to see and initial files before P.A.'ed. To be exercised in making approximate estimates on the "square" system and comparing with detailed estimates as a check.

2. Organising Works.

Officers given small works to execute instead of contractors by lump sum. Make small contracts by trades, or distribute work by piecework to civilians and R.E. Estimate profits by keeping records of work done (by square system) for money earned and compare with prices given. Arrange duties of staff, provision of stores, working of transport, etc.

3. Execution.

Officers given latitude as to choice of materials and prices. Study market and civil outside practice.

Officers given latitude in fixing fair rates of labour by piecework and daywork.

4. War Office Control.

By visits—(*a*) to give advice and assistance, (*b*) to control by inspection of Results.

W.O. Inspector of Works, assisted by

A. *W.O. Information Bureau.*
   (*a*). Type designs Branch.
   (*b*). Market supply, lands, contracts, etc., Branch.

B. *Consulting and Travelling Inspectors* who are specialists for
   (*a*). Designs and materials.
   (*b*). Water supply.
   (*c*). Drainage.
   (*d*). Electric lighting, gas, machinery.
   (*e*). Organisation, contracts, lands, finance.

These travelling Inspectors circulate information between Districts, and also keep the W.O. up to date.

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ORGANISATION AND TRAINING OF FIELD ENGINEERS.

By 'QUOTA.'

SOME interesting articles on this question have been published at various times, but they all appear to assume that the organisation of R.E. units should be based on war considerations. It may sound almost like a paradox to question this assumption ; and yet I venture to think that, to make any practical headway in the matter, it is better first to consider our peace conditions.

Under ideal circumstances, with a treasury pouring out gold into the army coffers, it would be folly to allow anything to stand in the way of making our organisation as perfect as possible for war ; but unfortunately these circumstances are ideal ; economical efficiency is more likely to be the watchword of the future than real efficiency. It remains for us to make the best of the matter, and to become as efficient as possible for war provided always no large peace expenditure is entailed. The question whether the policy is sound or unsound is not a subject for discussion ; the fact remains that it is the actual policy ; and that being so, it must occupy a position of first importance in any discussion on organisation in the army.

There is no doubt that this is perfectly well realised by the army in general, and that many an elaborate scheme, after being propounded and discussed in army circles, is finally crushed by someone observing that economy forbids. It would be much better to start with this principle instead of introducing it at the end to demolish castles in the air. Applied to our Corps it reduces the question of how best to organise R.E. units for war to how best to organise R.E. units for peace and still leave them as efficient as possible for war.

To answer this question is a very different matter to propounding it. To answer it perfectly would be to produce a scheme whereby R.E. units performed efficient and economical public service of an instructive nature in peace time, and yet remained able to leave this work for occasional periods of military training, and eventually, when war broke out, to drop it altogether and take up effectively the numerous war duties of R.E. troops.

Such economical peace services are particularly difficult to find for

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units organised in anything approaching large numbers. It may occasionally be possible to employ a company as such on useful work in peace time, but the opportunities of doing so are extremely rare. The only really practical way out of the difficulty seems to be to reduce the peace strength of R.E. units to skeleton dimensions and devise means for filling up this skeleton in time of war.

The system of reservists of course effects this to some small extent, but there seems no valid reason why this system should not be carried much further. There are some special reservists who have never served in the regular army at all, and who join the regulars only in war time; such men did particularly good service in the South African war. While not advocating an exactly similar arrangement I should propose something on the same lines but on a much larger scale.

Special reservists would form by far the majority of the R.E. companies. They would pass through their recruit's training as volunteers, or perhaps as regulars doing a six months' course in the Training Battalion, and would then at once join the reserve. Instead, however, of their never serving with the units in peace time, it would seem possible to arrange for their joining company headquarters for, say, a month's training every year.

The company headquarters would then consist of some 20 N.C.O.s and men under one officer. The remainder required to bring it up to war strength would be employed on their technical work in peace time, and would be usefully gaining experience at their trades; they would either be in government employment, or on some of our large railways, or perhaps with some big firm of contractors. To compensate these employers for the inconvenience of losing their men for the yearly training or for war, and to induce employers to engage special reservists, some small subsidy should be allowed by government, just as is now done to register horses. To compensate the men for their military obligations, they should receive a retaining fee as reservists do now and a comparatively high wage while training or on actual service.

The expense entailed by this would be more than covered by the large reduction in the number of regulars. The civilian employers would not necessarily suffer much from the annual loss at the training periods, because each company in any particular branch could do its training at a different time.

The method of training and employing the N.C.O.s offers more difficulties. These, however, might be drawn from among those who have served in the regular portion or nucleus of each company; and as, owing to their small numbers, it would be possible to afford them a good rate of pay, it should attract a very good class from whom to select. In order to ensure a sufficient supply, N.C.O.s could be drafted into the reserve after a comparatively short service,

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and there continue to receive advances in promotion. Each company would of course retain its own reserve with its own N.C.O.s.

Under these conditions it would be possible for N.C.O.s and men to become thoroughly acquainted with each other in peace time; and in war time, instead of nearly half the company being suddenly formed of reservists who neither know each other, their N.C.O.s, or their officers, a company would already be in the eminently desirable condition of the happy family.

The ordinary reserve required to make good casualties would be maintained as it is at present, only a smaller number would be required.

No provision has been discussed for training in larger units than companies because, although this is greatly to the advantage of the officers, nothing of importance is thus gained for the N.C.O.s and men. While training, however, the company would be at full war strength, and this is at present an unattainable desideratum.

The employment and training of the company officers is a much more difficult question, and it is on the possibility of effectively arranging this that such a scheme as the one proposed must largely depend. The officers of each company should, as far as possible, train with it in the annual course, and in the meantime they must somehow be usefully employed. A greater use of the present system of giving civilian or semi-civilian employment, with a regular period of company routine work, might meet the case. For instance, in addition to the officers permanently with the company, at least one other might be employed (as Division Officers are now) in such a way that a month's course a year would be possible. To make up the full establishment a greater number of officers than is now the case would have to be lent for purely civil occupations. These would be unable to take the regular month's course of training each year, but would instead be compelled to do purely military service for at least one year in five; while they were on civil work army funds would of course be relieved, though possibly a subsidy might again be necessary in the shape of part payment from army funds. It might also perhaps be arranged for junior officers to be attached to regiments for a year or so after leaving Chatham, to go through the regular routine of regimental duties; and, being freshly imbued with the latest ideas, they might be useful for fieldworks instruction.

There is yet another point to be considered and that is the employment of the company nucleus when not training. It may be assumed that this would consist of picked men of a high educational standard, encouraged by good pay and prospects of joining the non-commissioned ranks. The usual company routine would be reduced to a minimum because of the small numbers to be dealt with, and great facilities could be given for more advanced training and instruction.

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In conclusion I should like to add that, as no real solution of the question can be arrived at without exhaustive discussion and criticism, there has been no attempt to suggest more than the merest outline of a scheme for R.E. organisation; that this scheme could only be applied by degrees; and that it would of course be unsuitable for units, such as the Bridging and Balloon Companies, which are organised for specialised war services.

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THE FORTRESS INCUBUS.

By COLONEL E. M. LLOYD, LATE R.E.

A DISCUSSION has been going on in *The Times* under this heading which is of some interest to officers of the Corps. It was started on September 9th by 'Our Military Correspondent,' the writer of the luminous articles on the Russo-Japanese war which have been lately republished.

In the first months of the war he argued forcibly against any attempt on the part of the Japanese to drive the Russians completely out of Manchuria. By getting possession of Port Arthur, Korea, and Vladivostock they would 'sever the vital chord,' and put an end to the dominion of Russia in East Asia. "Port Arthur in Japanese hands is unassailable by land; Korea can be defended for the greater part by a chain of defensive works across the 100 miles of the narrowest part of the peninsula on the principle of Torres Vedras; even if Vladivostock cannot be held indefinitely against the might of Russia, which remains to be proved, it can be stalemated and rendered useless by the occupation of the islands commanding the entrance to the port."

If the loss of these places would be the loss of East Asia it would seem to follow that Russia was right to hold on to them. But in April the Correspondent spoke approvingly of Dragomiroff's advice, that Port Arthur should be evacuated. In June he described it as a 'marine trap,' likely to prove the ruin of the Pacific squadron and of the Russian strategy on land. He recalled the words of Lord Salisbury in 1898:—"I think Russia has made a great mistake in taking Port Arthur; I do not think it is of any use to her whatever." Lord Salisbury was no doubt looking at the matter from a political point of view, and was not free from bias. Sir George Clarke, no devotee of fixed defences, remarked at the time:—"There is probably no naval or military officer in this or in any other country who would agree with this opinion. . . . For the moment Port Arthur and Talienwan are no sources of strength. In less than ten years the Russian position in Manchuria will be unassailable, and Port Arthur, having regard to its geographical position, will be quite as strong as Cronstadt or Sebastopol. In substituting Port Arthur for Vladivostock as her principal naval station in the Far East, Russia gains immense advantages" (*Russia's Sea Power*, p. 152). He assumed, of course, that the necessary steps would be taken to turn

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these advantages to account. He credited Russia with an energy and ability which have been more conspicuous on the part of her antagonist, and he reckoned on a margin of time which was not allowed her.

But even under the actual conditions Capt. Mahan held that Port Arthur was a valuable asset. In the middle of August, 1904, after the failure of the last sortie of the ships, he wrote :—"Whatever the cause and wherever the fault, Russia, though much the greater in ultimate resources, permitted herself to drift into war unprepared, and gravely inferior in force upon the decisive scene of conflict. This was especially the case upon the sea, the control of which was, and has continued, so absolutely essential to Japan that apart from it she would be helpless for the offensive action she had to take. Under these circumstances two things were necessary to Russia—delay in order to gather her resources, and promptitude in repairing the neglects of the past. Herein appears the importance of Port Arthur : it has obtained delay. The time occupied in the siege has been ample for a government which recognized that the whole Japanese movement turned upon the control of the sea, to have despatched a fleet which by this time could have reached the scene, and very well might have turned the scale—allowing only for the fortune of war."

"If the Japanese decide to attack Port Arthur," said the Correspondent (June 15th), "we shall witness either the apotheosis, or the unregretted demise of the first-class fortress." It seemed not unlikely at that time that Metz and Sedan would be repeated on a smaller scale, that Port Arthur would soon fall into Japanese hands and Stackelberg's relieving army be cut off. These things, however, did not happen. Port Arthur held out for eight months, and its garrison paralysed three or four times their own numbers. By so doing they were of the utmost service to Kuropatkin when he took the offensive in October and fought the battle of the Shaho, and they gave the Baltic Fleet, which was then leaving Libau, more than two months to reach the Pacific.

Seldom has expenditure on fortifications been more fully justified, if we recognize that it is their part not to gain victory but to gain time. But the result did not lead the Correspondent to admit that he had made a mistake. He continued to argue that Port Arthur had been an incubus to the Russians and ought to have been abandoned : "Port Arthur has been a far worse entanglement to the Russians than Ladysmith to the British in South Africa" (December 17th). The comparison reminds one that, if Ladysmith had been provided with siege guns in storm-proof batteries when it was made a store depôt, it would have been no entanglement at all.

Since the war came to an end the Correspondent has gone on from the particular to the general. He allowed at first that "fortification, intelligently employed and kept in its proper and very subordinate

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place, is useful," and that naval arsenals should be secured against raids. It was the creation of a vast place of arms defended by 30,000 men and 400 guns that he quarrelled with (June 15th, 1904). Perhaps reflection showed him that if the thing is worth doing at all it may be worth doing effectually. At any rate, in his article on 'The Fortress Incubus' he is not careful to discriminate between the different classes of defensive works. He appeals to history to show that "fortresses, forts, and fortified positions are nothing but an incubus"; not a single instance is given to exemplify the right use of them.

In his comments on Turenne's campaigns Napoleon wrote :—" Il est des militaires qui demandent à quoi servent les places fortes, les camps retranchés, l'art de l'ingénieur ; nous leur demanderons à notre tour comment il est possible de manœuvrer avec des forces inférieures ou égales sans le secours des positions, des fortifications, et de tous les moyens supplémentaires de l'art." In his remarks on Rogniat's book, he said that Vauban's system of fortresses had saved the capital when Louis XIV. met with reverses, and again in 1793, and that Paris itself ought to be fortified. While field fortifications are "always useful, and never hurtful, if they are intelligently made," he was against relying on extemporised fortresses (places du moment) as Rogniat proposed ; they would need very large garrisons and their ill-protected magazines would be destroyed by shells.

Ignoring these well-known utterances, the Correspondent called Napoleon (as he also called Vauban) as a witness on his behalf, and quoted a passage from a letter to Eugéne Beauharnais (January 20th, 1807) :—"Les places fortes sont souvent embarrassantes, affaiblissent une armée, et sont la cause de la perte d'une bataille ou d'une campagne." A guileless reader might conclude that the Emperor is here discouraging his stepson's *penchant* for fortifications ; nothing of the kind. Napoleon had told Eugéne four months before to put Osopo, on the upper Tagliamento, in a condition to stand a siege. It should be capable of defence by 500 men, but fit to receive ten times that number. He was dissatisfied with the project which Eugéne sent him, and it was in criticising it that he incidentally made the above remark.

This is a fair illustration of the Correspondent's method of argument. A review of the great war from 1792 to 1815, made in the same one-sided manner, is said to show that armies and countries were either ruined by fortresses or drew from them no serious advantage, and this lesson is said to be confirmed by the war of 1870. The article drew several letters in reply ; some (from naval officers) supporting its conclusions, others calling in question the writer's version of the facts, or bringing forward fresh ones. Of the many points raised only a few can be touched upon. Colonel Hale dissented especially as regards the latter end of the war of 1870, 'the People's war' :—" Admitting,

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but solely for the sake of argument, or rather of avoiding argument, that during the first war the three fortresses he names, Paris, Metz, and Belfort, were each an 'incubus,' we find in the second war that, but for the counterbalancing influences of social and political passions, and of military incompetency in high places, the fortresses of France, including in that term Langres and the northern fortresses, would have proved to be the salvation of France."

'Minimus' pointed to St. Jean d'Acre as an instance of a small place which had arrested Bonaparte, and Fort Bard as one which checked him and threatened to baffle his plan of campaign. The Correspondent dealt with these two cases at some length and with some asperity (September 23rd and October 14th and 23rd). He denied that Bonaparte's discomfiture at Acre was due to "the rotten walls and towers of that miserable seaport"; it was due to the British navy. This could only mean that the walls were superfluous, and that the Turks, with the aid of Sidney Smith's sailors, could have beaten the French army in the open field. He went on to argue that, having taken three places out of four, Bonaparte had practically done what he wanted to do, and it was time for him to go back to Egypt. The two months' siege, the eight assaults, the loss of men and prestige, Napoleon's own language about 'cette misérable bicoque' were left unnoticed.

As to Fort Bard he accepted Napoleon's statement that it did not delay his march for a day. We know that Berthier discovered on May 19th that Fort Bard presented a 'very serious obstacle'; that Lannes was told that the fate of Italy and perhaps of the Republic depended on its capture; that as he could not take it, he was sent on by mountain paths to hold the mouth of the Val d'Aosta as best he could with infantry alone; and that it was in the night of May 24th—25th that the first French guns (two 4-pounders) were taken through the street of Bard under the guns of the fort. Whether this actually meant delay or not matters little; there must have been something wrong with the works or with the garrison for such a thing to be done at all.

Of the defence of Genoa by Masséna the Correspondent said:—"There is nothing to show that all the great results of the Marengo campaign would not have been as well or better obtained had Masséna retired upon Suchet instead of holding Genoa and being forced to capitulate." This, as 'Minimus' pointed out, was not Napoleon's opinion. He wrote to Masséna that he had a fine position at Genoa, which he should make the most of, to engage the enemy's attention while the reserve army was descending into Italy. He should keep four-fifths of his men there, and not fret about his communications with France. So in his comments at St. Helena Napoleon blamed Masséna for not having drawn Suchet to him. The wish to get possession of Genoa, which was known to be starved out,

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detained nearly half of Melas's army there for ten days after the reserve army had reached the plain of Piedmont. In a work lately issued by the German General Staff (*Die Festung in den Kriegen Napoleons und der Neuzeit*, reviewed in the July number of the *R.E. Journal*) the defence of Genoa is given as an example of the right use of a fortress, to further the plan of campaign by self-sacrifice if need be.

Torres Vedras, which the Correspondent had proposed eighteen months before to take as a pattern for the defence of Korea, now came in for its share of disparagement.

"The virtues of the parapets of Torres Vedras have been exaggerated. When Wellington retired upon these lines he collected within them 120,000 men of the armies of three nations, 70,000 of these consisting of regular troops, while Masséna began the invasion of Portugal with only 56,000 men and 100 guns. The defence of 50 miles of fortification, containing 150 forts and 600 guns, was a source of anxiety to the British commander, and when the French came upon the ground, on 10th October, 1810, there were eight or nine miles of the first line of works without garrisons. But for Reynier's sluggish action, they might almost have been captured without a fight." Here the Correspondent suggests, without saying it in so many words, that Wellington was quite strong enough to beat Masséna in the open field, that there was no need for him to fall back on Lisbon, wasting the country and driving in the population, and that the works behind which he sought shelter were in fact a danger to him. It would be a heavy blow to his reputation if this were true. Yet Napoleon, when Foy reported the situation to him in November, said:—"Lord Wellington s'est comporté en habile homme; cette désolation totale d'un royaume est l'effet de mesures d'ensemble habilement concertées. Je ne pourrais pas faire cela, moi, avec toute ma puissance." Lord Roberts gives this retirement into the lines of Torres Vedras as one of the instances of Wellington's masterly combinations which took the enemy entirely by surprise.

General von der Goltz says that if the Turks had followed Wellington's example in 1877 the Russians would have been forced to retreat.

It must be remembered that in March, 1809, less than two months after Moore's army had been driven out of the Peninsula, Wellington had ventured to affirm that Portugal might be defended, whatever might be the result of the contest in Spain, by 60,000 regular troops, half of them British, assisted by 40,000 Portuguese militia. Six months later, when the war with Austria was coming to an end, and there was reason to expect that the whole force of France would be brought to bear on the Peninsula, he again declared that Portugal might be held, or that at all events the British army could be brought away. It was then that he began his works at Torres Vedras, and

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any judgment upon them must take account of the possibilities at that time, and not merely of the force which Masséna actually brought against them. Wellington stood almost alone in his confidence. As Lord Liverpool afterwards wrote :—"All the officers in the army who were in England, whether they had served in Portugal or not, entertained and avowed the most desponding views as to the result of the war in that country," and leading members of Wellington's staff wrote home in the same strain.

But if we look only to the actual invasion Wellington's strategy was fully justified. In September, 1810, the French had 280,000 men present under arms in the Peninsula. Masséna had 65,000 men with him, according to Napier, and a corps of 19,000 men was to follow him. He also counted on assistance from Soult. Wellington had only 50,000 men, of whom half were newly-raised Portuguese, when he made his stand at Busaco. He could trust his troops to hold such a position against direct attack, but not to manœuvre in open country against an enemy twice as strong in cavalry; so when the position was turned he fell back to Torres Vedras. There he found reinforcements which brought his regulars up to 66,000, and the Portuguese Militia served to garrison the works. Masséna, who had lost 5,000 men at Busaco, did not venture to attack them. He waited for reinforcements, which reached him in December but did not make up for his losses by sickness.

Whether Wellington should have taken the offensive at that time, when he had the advantage in point of numbers, is of course a separate question, which has little to do with the Lines. "It has been suggested in Germany," says the Correspondent, "that Wellington's failure to crush Masséna, in view of the British general's superiority of numbers, should rather rank as his greatest failure during the war." Wellington discussed the question fully in a letter to Lord Liverpool (December 21st). He came to the conclusion that it was better to leave Masséna alone, although there was a good prospect of success if he attacked him. "Our business," he said, "is not to fight the French army, which we certainly cannot beat out of the Peninsula, but to give occupation to as large a portion of it as we can manage." When Masséna retreated to Spain in the spring he had lost 30,000 men.

We suffer in England, according to the Correspondent, from "our thoughtless predilection for so-called strong places, chiefly owing to the absence of a trained General Staff, and of the resulting doctrines based upon careful and impartial study of the art of modern war." The work already mentioned (*Die Festung in den Kriegen Napoleons und der Neuzeit*) shows how widely the doctrine of the German General Staff differs from the views which he puts forward. It maintains that railways have given fortresses, both large and small, a new value, and that all officers should

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concern themselves with siege warfare more than they have done hitherto. The Correspondent says that in 1870 "the French fortresses played an important part in the ruin of their army and their country," and he mourns over the blindness which led France to spend 67 millions after the war on fortifications and armaments. Why does he omit all mention of Germany, which has been strengthening her fortresses from that time to this, is now making an outer chain of forts at Metz, and is building forts near Basle to guard against a French invasion by the gap of Belfort? In fact, as Colonel Henderson has said, "since 1870 it has been recognised that preparation of the theatre of war is one of the first duties of a Government. Every frontier of continental Europe is covered by a chain of entrenched camps. The great arsenals are amply fortified and strongly garrisoned. Strategy has as much to say to new railways as trade; and the lines of communication, whether by water or by land, are adequately protected from all hostile enterprises" (*Science of War*, p. 15).

There is not much sign at present of a predilection for strong places in England. The absence of a trained staff with a settled body of doctrine tells, but in another way: it makes military opinion unstable, and tempts brilliant writers to go all lengths in whimsical paradox.

It is an old maxim, if you have a weak case abuse the other side's attorney. The Correspondent indulges freely in gibes at the Troglodyte school, "who have misdirected our efforts for half-a-century." Engineers, he says, are good servants but bad masters. This is putting the saddle on the wrong horse. It is a question of strategy, not of engineering, whether, and to what extent, particular points should be occupied. Of course engineers are as much entitled as other soldiers to form and express opinions on that question; but does anyone suppose that Napoleon, for instance, left them to settle it? Troops must separate to live and move, yet concentrate to fight; that is the great problem of the military art, and its solution depends on ever-varying conditions. No one laid more stress than Napoleon on mustering in strength on the field of battle; yet he left 150,000 men behind him in German garrisons when he retreated across the Rhine in 1813. It was part of his theory, though not always of his practice, that garrisons should consist of troops not fit to fight in the field and should leave the field armies undiminished. When the strategist has settled what detachments he will make, what points he will hold, it falls to the engineer to do what he can to enable small forces to hold those points securely; and no unprejudiced critic will deny that he can do a good deal.

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LANDSCAPE DRAWING FROM A MILITARY POINT OF VIEW.

By Col. L. G. Fawkes, late R.A., with Note by Capt. R. F. Jelley, R.E.

In reply to Capt. Vickers' question in the April number of the *R.E. Journal* I venture to think that the art of landscape drawing has the following military uses :—

(1). Panorama sketches of country occupied by the enemy, as seen from an advanced position, would be a very great help to the officer commanding a force, giving him an idea of the character of the country over which he was likely to move.

(2). Such sketches are most useful in enabling ranges to be picked up quickly. Lieut. R. H. Thomas, R.G.A., showed me a panorama excellently drawn by him when he was in charge of a 4·7″ gun in the war in South Africa ; the ranges to the successive ridges were shown on the sketch, which represented the whole surrounding landscape divided into sections of 10°, the bearings being marked ; the ranges had been ascertained either with a range-finder or by trial shots.

(3). Outline panorama sketches were much used in the South African War as a quick method of indicating an objective. In this kind of sketch conspicuous points, such as houses, trees, etc., should be carefully drawn so that there can be no difficulty in identifying them.

(4). As the art of making topographical sketches educates the eye for ground, so the observation necessary to make an intelligent landscape sketch practises the eye in seeing gentle slopes, which are often unobserved but are very important for an officer who is to teach his men to make use of ground.

A knowledge of the principles of perspective will be found essential and will often save a man from being misled by the deceptiveness of ground.

Parallel lines, such as the sides of a road, furrows, telegraph posts, etc., are often met with ; and when these recede from the eye their vanishing point should be looked for, as it is only thus that the slopes of the ground can be correctly given in a sketch. For example, if the slope ascends from the observer, all receding parallel lines on that slope will have their vanishing point above the horizon ; if it descends, the vanishing point of these lines will be below the horizon.

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In *Fig.* 1 there is a watercourse crossing the footpath *abc* at *b*; and in *Fig.* 2 there is a ridge crossing the footpath *def* at *e*; the angles at *b* and *e* would indicate this at once to an observer standing on the other side of the footpath. In these figures V, V_I, V_{II}, V_{III} are the several vanishing points, and HH′ the horizon.

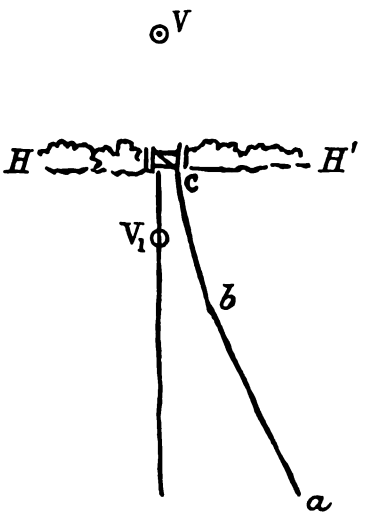

Fig. 1.

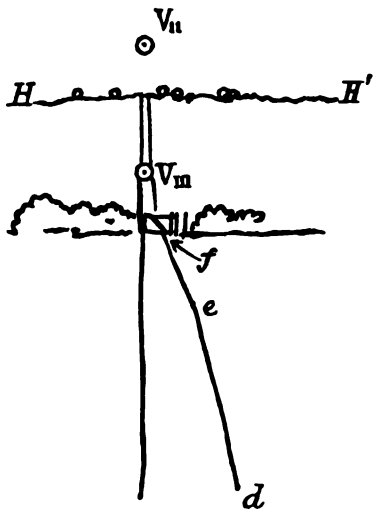

Fig. 2.

In such sketches no time should be wasted in unnecessary shading. Characteristic lines should be selected. Every line should be drawn with deliberation and have a meaning. An unmistakable representation of every feature of tactical importance, such as artillery positions, folds of ground, farms, woods, roads, railways, etc., should be aimed at rather than an artistic sketch.

No near foreground is required, and this simplifies the drawing of trees. The conventional sign for trees in topography can be used, care being taken to make their size proportional to their distance from the observer. Where avenues of trees or edges of woods recede from the observer, they should be placed behind one another as in *Fig.* 3.

Fig. 3.

The accompanying *Plate* shows outline sketches of the battlefields of Woerth, St. Privat, and Spicheren as examples of this kind of work.

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In forwarding the above remarks, kindly written for the *R.E. Journal* by Colonel Fawkes, I venture to anticipate two points that may be raised in objection to landscape drawing from a military point of view.

The first is that a camera might take the place of a landscape sketch; and the second is that landscape drawing cannot be efficiently undertaken by any but good draughtsmen.

With regard to the employment of a camera, there is (disregarding the mechanical difficulties of apparatus and reproduction) a great difference between the military values of a photograph and a landscape sketch. The "base" (*i.e.*, the distance between the point of sight and the picture plane) in a photograph is so short that, in order to see the view in true perspective proportion, the photograph must be held uncomfortably close to the eyes. In a sketch, the "base" can be fixed at such a length as to obviate this objection; the length of one's arm forms a convenient and excellent "base."

As regards accuracy, the freehand sketch should and can be easily made with absolute accuracy. As Colonel Fawkes points out, only the characteristic lines should be selected; so that, instead of the bewildering detail of a photograph, a clear and vivid picture is obtained.

With regard to the necessity of being a good draughtsman, this is quite an erroneous idea. With a little patience and effort, a poor draughtsman has nothing to fear about being able to turn out a useful and intelligent sketch. A little consideration will show him that a landscape sketch can be *mechanically* constructed with absolute accuracy.

As a first essay, let the poorest of draughtsmen use a plane table and draw rays to the guiding points in any view. Let him then rule an "horizon," which will be intersected by the rays. The vertical distances from the horizon are then plotted by observing the gradients and laying off the required proportion of the rays.

From these leading strings, he can soon fearlessly advance to the method of holding up the pencil at arm's length and measuring in this way. It will soon be evident that landscape sketching from a military point of view is one of the easiest and most useful methods of training the powers of observation.

R. F. JELLEY.

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A TIME-ALTITUDE AND SOME OTHER DIAGRAMS.

By CAPT. D. BRADY, R.E.

AMATEUR astronomers, like other amateurs, are very keen about rigorous precision. The probable error of their observations may be ten seconds or more, but they work out their results to decimals of a second of arc. By the time they have become good observers their tedious computations have killed their keenness; and then, instead of using five-place, or even four-place, tables of logarithms, and ceasing to bother about fractional corrections, they simply cease observing and presently forget all about it. For work-a-day use few people want to know the error of their watches to the last second, or the very precise azimuth of a star.

I do not know of any book or pamphlet that describes graphic methods for solving spherical triangles, that is on a flat drawing-board without computation. Perhaps then the following examples may be of interest.

Results good enough for many purposes may be got by using a good straight-edge, a good protractor, and a sharp pencil, and drawing *big*. It would be absurd to suppose that for precision drawing can compare with calculation. Still, when much may depend on a result and it is therefore calculated, a diagram made with moderate care may not only serve as a useful check against *gross* error but also show, by the boldness of the intersections, whether the observation was "well-conditioned."

Like other graphic methods, the drawings may be used as mere diagrams, and the precise values of the angles computed; but as they are not specially arranged for the use of logarithms, the computation may not be the shortest.*

ϕ is the Latitude.

δ is the Declination of the star (or sun or planet). δ is treated as positive when the observer and the star are both north of, or both south of, the equator; it is to be counted negative when the observer and the star are on opposite sides.

t is the Hour-Angle, that is the arc of the equator separating the meridian of the observer from the meridian of the star.

* The first and second diagrams, with a few lines added, fully represent the ordinary formulæ for $\sin^2 \frac{t}{2}$ and $\sin^2 \frac{A}{2}$.

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A is the Azimuth of the star. In the examples it is reckoned from the pole nearest the observer. Astronomers reckon from the other pole; so if the ordinary astronomers' azimuth is required, the supplementary angle must be taken.

h is the true altitude of (the centre of) the star, that is the observed altitude (corrected for instrumental errors) + parallax − refraction. Parallax and refraction may be ignored in graphic solutions.

The Apparent time must be corrected for the difference between Mean and Apparent time (the "equation of time"), and for the distance in longitude (at the rate of 4 minutes for each degree) between the place of the observer and the standard meridian.

To use the Time-Altitude card as a star-finder, all that is necessary is that it should be gummed or tied to the telescope so that the "shadow-line" is parallel to the the telescope. Of course the declination scale and the time scale must be extended to suit the stars wanted. By the use of the Time-Altitude card the altitude is pre-determined; it is only necessary to swing the telescope to find the star.

I have given no detailed explanations with the diagrams; readers of the *R.E. Journal* are not likely to want any. Those interested will no doubt invent other diagrams to suit their particular problems.

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*WITH THE PONTOON TROOP IN NATAL, 1899—1900.**

By Bt. Colonel J. L. Irvine, R.E.

PART III.—VAALKRANTZ.

After the retirement from Spion Kop the Pontoon Troop moved to Spearman's Hill, and on the following day, January 29th, returned to its former camping ground near Potgieter's Drift. Increased rations were issued to the whole force, and for the next week the bulk of the troops took a good rest. We busied ourselves repairing and rearranging our equipment, and on the 1st of February threw a "heavy" pontoon bridge (No. 3) across the Tugela at the cutting where the pont usually worked and where the bridge had been thrown across before. In the meantime the 17th and 37th Companies, R.E., were busy blasting and making a road up the south side of Zwaartkop, a high hill to the south-east of Potgieter's Drift and overlooking Skiet's Drift. The Naval guns on Mount Alice carried on a desultory bombardment of the Boer trenches on Brakfontein, where parties of the enemy could occasionally be seen working.

The bridge at Potgieter's Drift, begun at 5.30 a.m., was completed by 9 a.m., and at 1.15 p.m. we again paraded to construct a second bridge north of Zwaartkop. But our infantry working party for digging the ramps and our covering party did not arrive till 2.45 p.m. and the work was not commenced until 4 p.m. The site chosen for the bridge was at a re-entering bend of the river below Zwaartkop, and about half-way between it and the kopjes (commonly known as "Mackonochie Kopjes" from the nature of the ration issued there) in front of Potgieter's Drift, which were occupied by the Rifle Brigade and Durham Light Infantry. The bed of the river was well under cover, being protected from Vaalkrantz by a ridge; but otherwise the conditions for bridging were not very favourable as the banks were about 30 feet high and almost perpendicular, and the stream was strong on the far side; the banks had to be trimmed off to admit of the pontoons being slid down and launched. On the near side four trestles were placed, then eight pontoons, and finally one trestle on the far side, in all 70 yards. As the bridge was required for the passage of artillery only, a "medium" bridge (No. 6) was built. The men worked most energetically, one of the sergeants and three or four of the men working up to their waists in the water, placing the trestles, for over two hours. About 7 a.m. when I sent them

* *Continued from previous number.*

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back to camp to get a double ration of rum, their faces were blue and their teeth chattering with cold; a few days later the sergeant got an attack of fever which laid him up for some weeks and was no doubt due to the chill he had got working in the water. The bridge was finished at 8 p.m. The ramp on the south side was made down a donga, that on the opposite bank up the face of the cliff; they were completed on the following day. It was very dark getting back to camp after the completion of the bridge and there was heavy rain.

On the 2nd February the Naval 12-prs. were hauled up the side of Zwaartkop with the assistance of the 37th Company, R.E., and ammunition was carried up by hand. The road up the hill was a very difficult one, and for 100 or 150 yards seemed almost impossible, as it went straight up the face of the kop at an angle of about thirty degrees. Two 15-pr. field guns and the guns of the mule battery were also mounted on the top. The position of the guns was masked by the branches of the mimosa trees growing up the north face and on the top of the hill, and the Boers, although no doubt they knew of their presence, appear to have thought that they were intended to cover the passage of the troops at Skiet's Drift.

On the evening of February 3rd Sir Redvers Buller had a conference of Commanding Officers at which he explained his arrangements for the attack on the Boer position on the following Monday, February 5th.

The enemy's lines were in the shape of a large semi-circle, with their right resting on the conical-shaped hills to the east of Spion Kop. Here, in well-placed epaulments, were some guns from which our Naval 4·7″ guns on Mount Alice were unable to draw any reply until the attack took place. From these hills a high ridge known as Brakfontein, sloping gently down to the river, extended in an easterly direction till it reached a chain of hills curving gradually southwards and ending in the Vaalkrantz position. Over the centre of the Brakfontein ridge ran the road from Potgieter's Drift to Ladysmith. At the southern extremity of Vaalkrantz lay Munger's Farm, in the valley, with a deep donga running close to it and joining the Tugela near Munger's Drift, a crossing which is practicable only at certain times when the river is low. Behind Vaalkrantz extended a gradually rising open plain, ending a few miles away in a ridge, named Roodepoort, behind which at some distance was Ladysmith. The whole distance to Ladysmith was 15 or 16 miles. South-east of Munger's Drift rose a forbidding-looking range of hills, Doornkop, extending in a southerly direction to Skiet's Drift and forming the left of the Boer position. In front of Doornkop were some smaller grass-covered hills and the valley below was planted with crops of maize, now very tall and nearly ready for harvesting. The whole of Brakfontein and the hills near it were most elaborately

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covered with trenches, and any attempt to force them would have meant death and defeat to any one daring to attack. The entrenchments gradually weakened towards the east, the Boers apparently not anticipating an attack between Brakfontein and Skiet's Drift, but trusting for cover in this part of the line to the natural difficulties of the ground and to a few stone walls. Along the whole of the front of the position ran the Tugela, fordable only at Potgieter's and Skiet's Drifts.

The British position was much less extended, and had the advantage of forming the chord of the circle of which the Boer lines formed the circumference. It extended from Spearman's Hill and Mount Alice, where the 4·7″ guns were posted, on the left, to Zwaartkop, overlooking Munger's and Skiet's Drifts, on the right. In the centre, on a low hill, were posted the 5″ guns. In front of our left centre was Potgieter's Drift, protected from the enemy on Brakfontein by the semi-circle of low kopjes on the north side of the river; these were occupied by our troops and formed a natural *tête-de-pont*. Sir Redvers Buller's plan was to cross at Munger's Drift and attack the left centre of the Boer position at Vaalkrantz, and so open a road across the plain to Ladysmith, at the same time making a feint on the Brakfontein trenches; and certainly, as seen from the top of Zwaartkop, it looked as if the scheme had the elements of success.

From our splendid artillery position the eastern section of the Boer stronghold could be plainly seen. Of this portion of their defence the long hill Vaalkrantz formed the centre, and the impression gained from the bird's-eye view obtained from the top of Zwaartkop was that once we were in possession of Vaalkrantz we should be able to take the trenches on Brakfontein in reverse. Besides this, Vaalkrantz commanded the plain leading to Ladysmith, and formed a good position, when in our hands, for covering the passage of the river. It is true that Vaalkrantz itself was commanded by Doornkop; but Doornkop was some distance away, and it was at that time unoccupied either by artillery or infantry; and, as far as one could see from our side, it was of so rugged a nature that the mounting of guns on the summit must be a difficult task. It all looked so plain and simple that one could not help wondering whether there was not some trap laid for us. A few of the tents of the Boer laager were visible behind Vaalkrantz, and more tents and a very much larger laager could be seen in the valleys which cut into the side of Doornkop; so that it was evident that this portion of their line of defence had not been entirely overlooked.

On the 3rd February the kopjes north of Potgieter's Drift were vacated by the Durham Light Infantry and Rifle Brigade, and occupied by General Wynne's brigade. General Lyttelton's brigade concentrated in the valley west of Zwaartkop.

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All the bridging equipment of the 17th and 37th Companies, R.E., was handed over to the Pontoon Troop, and in the afternoon of Sunday, 4th February, the "heavy" bridge (No. 3) at Potgieter's Drift was replaced by a "medium" one.

At 6.30 a.m. on February 5th, Lieut. Skipwith left camp with two "detachments" for No. 6 bridge to make it quite safe, as the rush of the stream had scoured away the gravel from under the trestles. Soon after this, the feint on the Brakfontein position began, supported by a heavy fire of artillery.

At 7 a.m. the 4th Brigade under General Lyttelton marched off, followed by the Pontoon Troop, taking the narrow road at the foot and north of Zwaartkop. Before this road had been cleared, instructions were received for the Pontoon Troop to move to the front; and the water and ammunition carts of the 4th Brigade, which were then blocking the narrow track, had to reverse and get out of the way, which they had some difficulty in doing.

On reaching No. 6 bridge, which had been made quite secure by Skipwith, who here rejoined us with his men, General Sir F. Clery gave me orders to get a bridge thrown across near Munger's Drift as quickly as possible and to report for further orders to General Lyttelton. Parking the wagons under the brow of a low ridge I rode on and reported myself to General Lyttelton, and accompanied him and his Brigade-Major to make a reconnaissance of the river. When about 500 yards distant I went on alone, creeping down a donga to the river bank. I found a most suitable place for bridging within fifty yards of the point where the donga joined the river. The bank on the near side sloped down gradually at an incline of about one in three to the water's edge; and though it was rather steeper opposite, there was no rock and the ramp would only have to be cut out of the earth. This was most fortunate; for if the banks had been of the same difficult nature as we found everywhere else on the Tugela, the bridging operations would have been extremely difficult, if not impossible. The whole of the valley on the opposite side of the river was covered right down to the water's edge with high-growing mealies. This was one of our greatest dangers; but so far as could be seen, the mealies were then unoccupied, even by scouts. Retracing my steps up the donga, I found a passage across it for the wagons and then reported to General Lyttelton. He ordered me to push on at once and make the bridge (No. 7) at the site selected, and detailed the Scottish Rifles to find the covering party. Sending Lieut. Skipwith down the donga with the dismounted men of the Troop and leaving Lieut. Ommanney to regulate the supply of material, I took the first wagon down to the water's edge, the remainder following as required at fifty yards distance. Two R.E. drivers were told off to each wagon as a precaution in case the Natives bolted, but fortunately their services as amateur ox-leaders and drivers were not required.

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The first wagon reached the river bank at 10.25 a.m.; and no sooner had the men started to unpack it than a heavy maxim and rifle fire was opened on us from the hill overlooking Skiet's Drift, about 1,500 yards distant. The guns on Zwaartkop at once unmasked, and, assisted by a battery of artillery in the plain below, tried to put down the enemy's fire; but the Boers were so well concealed that our fire had little effect, and they kept up shooting at the bridge right merrily. Our covering party could do little to assist us, so the construction of the bridge depended largely on the accuracy of aim of the Boer riflemen. The Zwaartkop guns also commenced the bombardment of Vaalkrantz, and before long had driven the Boers from it and set fire to the grass in several places. The reach of the river where we had to cross was enfiladed by the Boers on Skiet's Drift Hill, and the ground on both sides was almost treeless, so that it was impossible to get any cover at all while making the bridge; all one could do was to work away as quickly as possible and hope for success. The first three pontoons were placed "in bridge" without much difficulty, as the majority of the bullets hit the top of the bank about fifty yards on our right (down stream) and only an occasional bullet or ricochet came among us, without doing any harm. But all of a sudden a very heavy fire was opened, and the bullets spat into the water all round and hit the bridge and bank. It was a moment of intense anxiety, and a horrible thought went through my mind that possibly the construction of the bridge might be found impossible and that we might cause all the General's plans to fail. But after a momentary hesitation the men stuck to their work right well and went on almost as steadily as if we were not the target of the Boer rifles. The crew of the "anchor" boat had a particularly unpleasant time of it, for they had to row backwards and forwards among the falling bullets and lay the anchors as if nothing was happening; the two men on the bank, stocking the anchors and bending on the cables, had also a particularly nasty time, as they had to stay still in one place, and could not give vent to their feelings by running backwards and forwards with superstructure. Our first casualty was one of the rowers in the anchor boat, who got a very dangerous wound in the groin, from which however he eventually recovered.

In the meantime a portion of the 37th Company arrived, and started digging the ramp on the south bank. They were soon followed by the 17th Company who, as soon as they could be got across, set to work to make the ramp on the north bank. These men, equally with the Pontoon Troop, had to work exposed to the enemy's fire, and were unable to take advantage of any cover. The river was 70 yards wide, with a stream running at about two miles an hour. At 11.15 a.m., fifty minutes after commencing work, the last bay was put in; a signal was sent to the General, by a signaller of the Scottish Rifles, that the bridge was ready for the passage of infantry; and Lieut.

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Ommanney, who had arrived shortly before, was also sent to report. Twenty minutes later, finding the troops did not arrive, I rode off and reported the completion of the bridge (No. 7) to Sir Redvers Buller, whom I found sitting with Sir Francis Clery under a tree a short distance away.

When I left the bridge the firing had temporarily ceased, but it reopened with redoubled fury just as I got back. The Boers had used the interval to creep lower down, and a hot fire was now coming from the mealies at a range of from 600 to 800 yards. The fire was much more accurate than before and there were several casualties; and there is little doubt that, had the completion of the bridge been delayed, we should have lost heavily. The fire from the Boer maxim gun was also uncomfortably close, but fortunately always about twenty-five yards short; we always had time to lie down when we heard it begin, and in a second or two the bullets would cut the water just in front of us from bank to bank with a horrible hiss. It was probably due to the men lying down that the Boers never raised the elevation of their gun, as they may have thought that the bullets were going too high; with the slightest increase of elevation the maxim would have absolutely swept the bridge and few would have escaped. On the completion of the ramps all took cover in the donga and our total casualties were then found to be only eight men wounded; three in the Pontoon Troop, one in the 17th Company, and four, one of whom died of his wounds, in the 37th Company. With the exception of the man who was wounded in the anchor boat, all these men were hit when on the bank, and not a single man when working on the bridge. There were many holes in the pontoons and superstructure but no damage was done. Each non-commissioned officer had been previously supplied with wooden pegs, with which he plugged up any holes he could see; but even those that were not noticed did no harm, for the covering of the pontoons is so elastic that the bullet holes closed of themselves. Several men had very narrow escapes: in one case a bullet struck the wood between the legs of a man sitting on the thwart of a pontoon attending to the cables, and in another a bullet went between the fingers of a man carrying a chess. It was very curious to watch the men running to and fro on the bridge; they all held their heads down and slightly inclined to the side as if they were facing a heavy hailstorm.

In the donga we were practically safe except from an occasional dropping bullet. The bridge was left in charge of Lieut. Skipwith and Sergeants Newnham and Grist who volunteered to remain at the head of the bridge, a post of considerable danger if the Boers had crept closer through the mealies; but they soon made a shelter for themselves by excavating a hole in the side of the bank.

About 1.30 p.m. General Lyttelton's brigade began to cross, the Durham Light Infantry leading. They made a rush across the bridge

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and, turning to the left, formed up under the bank. The Boers reserved their fire until the troops rushed across the bridge, but again no one was hit when actually on the bridge, though several were wounded and killed on the bank just after they had crossed. After clearing the mealies of snipers the Durham Light Infantry advanced on Vaalkrantz, on which a very hot artillery fire had been maintained all morning by the guns on Zwaartkop and also by the artillery in the plain below. The latter had crossed by No. 6 bridge from their position in front of Potgieter's Drift, where they covered the feigned attack on Brakfontein, to the valley of the Tugela below Zwaartkop. By about 4 p.m. Vaalkrantz was in our possession, having been taken without very heavy losses.

The Pontoon Troop remained all night near the donga. At daybreak next day I sent Lieut. Ommanney for definite instructions about dismantling No. 6 bridge and forming another (No. 8) immediately under Vaalkrantz, while I walked along the river bank to find a suitable site. The Boers had mounted some guns on Doornkop during the night, and immediately after dawn an artillery duel commenced between them and our guns below Zwaartkop. It was a very curious sensation as I walked along, in perfect safety, to hear the shells screaming over my head from both directions. A hot shell and pom-pom fire was also brought to bear on Vaalkrantz, where our troops had built sangars and walls for their own protection during the night. On my way back to our bivouac I saw a large cloud of smoke rise from the top of Doornkop, and it was afterwards ascertained that our shells had exploded one of the Boer ammunition wagons.

Soon after breakfast orders arrived that No. 6 bridge was to be dismantled by the 17th Company and that we were to make a fresh bridge under Vaalkrantz. After a fruitless search among the crowd of troops of all arms gathered together at the foot of Zwaartkop, I found the Company waiting at No. 6 bridge, which they dismantled and packed by 10.30 a.m. I then took the wagons in very open formation across the plain to Vaalkrantz, where Lieut. Ommanney met me with the dismounted men of the Pontoon Troop. Lieut. Skipwith and the two sergeants remained in charge of No. 7 bridge at Munger's Drift.

No sooner did the enemy see us approaching the river below Vaalkrantz than they opened a hot shell fire from Doornkop. The first few shells fell rather wide, but they soon got the range to a nicety and planted shells all round us in a most unpleasant manner. Fortunately the shells had very small bursting power, and beyond making us a bit "jumpy" had no effect. One shell buried itself in the ground absolutely at the noses of the leading oxen of one of the wagons, but these patient beasts went on with their grazing as if nothing had happened. We had some difficulty in getting the native "boys" to bring up the wagons, and in some cases it required rather forcible

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entreaty to get them out of the dongas where they had run for shelter. One or two boys however behaved very well; particularly one who was conspicuous all through the campaign by a jauntily worn wide-brimmed black hat and by his martial bearing, and who saluted the officers on every possible occasion in a way that would have filled a drill sergeant's heart with pride. After a good dose of common shell the Boers turned on shrapnel, which they burst over us with great accuracy, but with little success, as only one man was wounded, his hand being ripped open when carrying a pontoon. I was more afraid of the men getting damaged by allowing the pontoons to fall than by the shells; for, when sixteen men have a weight of half a ton on their shoulders* and a shell bursts just over their heads, it is very difficult for them, however well trained they may be, to remain perfectly cool; and if one or two relax their hold, the pontoon almost certainly falls, and in doing so is very liable to strain the backs of those who continue to hold it.

Thanks to the assistance of our artillery, who, as soon as they saw what was happening, turned their concentrated attention to the Boer guns and in a short time silenced their fire, we at last got all our wagons unloaded and the pontoons launched. With the exception of the guns on Doornkop we were quite protected from the Boer fire, as a long low ridge lay on our left flank; and even the Doornkop guns could not see us once we got to work on the river, which here ran in rather a deep channel between steep banks. But beyond being able to work under cover we had not got at all an ideal place for bridging. The river was 85 yards wide, and four feet deep at the near and eight feet at the far side; this made it difficult for placing trestles, which we had to use as our stock of pontoons was exhausted. The banks, especially close to the water, were steep, and covered with long reeds and low willow bushes.

On the near side we placed four Weldon trestles and then ten pontoons, and we were still fifteen yards short of the opposite bank. We then placed two more trestles, using foot ropes and guys to get them in position. This was very difficult, as the river was eight feet deep and we could get no one to stand in the water to assist; and for the last trestle the bottom was uneven and the legs had to be of different lengths. When we eventually got over our troubles, a new difficulty met us. After joining up with the last trestle we found we had absolutely no superstructure left to bridge over the gap of eight or ten feet to the shore. This was an unpleasant predicament, as there was no timber anywhere near from which we could improvise material; and the only thing to be done appeared to be to build out a stone pier from the bank, which was likely to be a very slow and

* In unloading pontoons from wagons the pontoons are carried on the shoulders of two "detachments."

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laborious proceeding. Our good luck however again befriended us. Remembering that a small amount of spare superstructure had been left at both Nos. 3 and 7 bridges to replace any that might get broken, Ommanney went off to collect it, and returned in about an hour or so with just sufficient to reach across. If the river had been a few yards wider, we should have found ourselves in a very disagreeable position. The ramps were made by the 17th and 37th Companies, R.E., the former digging the one on the north bank and the latter that on the south.

General Lyttelton's brigade held Vaalkrantz all day, and the first to cross the new (No. 8) bridge were some of the wounded of the Durham Light Infantry. Unfortunately our troops, on occupying Vaalkrantz, found it was not the desirable position it appeared to be when seen from Zwaartkop. Instead of enfilading the trenches on Brakfontein, the latter were able to turn the tables on Vaalkrantz, and Doornkop was also in a position to bring a nasty fire to bear on the southern face of the hill; so that our troops were exposed to both a reverse and enfilade fire, and had they not been entrenched they would have suffered badly. Thus we practically found that, although the occupation of Vaalkrantz was a nasty thorn in the side of the Boers, we could not ourselves advance without being exposed to the risk of very heavy losses. The Boers were able to bring guns and pom-poms into position on the rear slopes of Brakfontein, where they were absolutely safe from our artillery fire from Zwaartkop. It was considered either impracticable or undesirable to attempt to bring our guns on to Vaalkrantz itself.

Towards evening, after a very heavy shell fire on the south-west face of Vaalkrantz, held by the Durham Light Infantry, the Boers made a sudden and determined rush on the position. Seeing the danger their comrades were in, the King's Royal Rifles, who were in reserve, rose from their trenches with ringing cheers, on hearing which the Boers turned tail and departed.

At dusk General Lyttelton's brigade was relieved by General Hildyard's, both moving by No. 8 bridge. A portion of General Hart's brigade crossed No. 7 bridge to relieve the troops holding Munger's Farm. The Boer guns on Doornkop opened fire on the bridge as they were crossing. They had hardly passed, and General Hart was still on the bridge, when a shell burst under his horse, but fortunately without doing him any harm. The burst of the shell broke six chesses and two baulks and made three large holes in the pontoon, but just above the water line, so that no real damage was done.

During the night the Boers made an attack on our right flank at Vaalkrantz, and later in the night another on the left flank, both without result.

The bombardment of Vaalkrantz, with guns, pom-poms, maxims, and

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rifles, went on all next day, ninety 6-pr. shells arriving with fair regularity from Doornkop; they did little damage, however, till late in the afternoon, when one burst right in the middle of where the East Surrey Regt. were lying. The boulders, which a moment before appeared entirely deserted, were now suddenly alive with khaki figures, who rushed out to find a new resting place. I was utterly astonished to see so many men there, for, although we were little more than 200 yards away, as long as they kept quiet it was almost impossible without glasses to distinguish them from the rocks themselves. The shell fell close to General Hildyard and his Staff, but they luckily escaped. No one was wounded by the shell, but one officer and five or six men were bruised and crushed by the rocks it set rolling. Soon after that two shells came in quick succession at the bridge; one, skimming close over our heads, struck the south bank beneath the roadway; the other struck the bridge, breaking a chess and chipping a baulk and the leg of a trestle. They must have been chance shots, for the bridge was absolutely out of sight from any part of the Boer position. The bridge was fairly crowded at the time with men filling water bottles, washing, etc., and it was amusing to see the rapidity with which it was cleared. It was very hot sitting on the face of the hill all day, but we relieved the monotony by having a delicious bathe; it was under rather novel conditions for occasional bullets kept on dropping in the water all the time.

About 6.0 p.m. a Staff Officer brought orders for a retirement, and one's heart sank at the thought of giving up the relief of Ladysmith; for it seemed that, if we failed here, no other course was open to us but to leave our beleaguered comrades to their fate. We did not know of the plans for the second attack on Colenso which Sir Redvers Buller had up his sleeve all the time. Soon afterwards I got written orders from the Chief Engineer placing the 17th and 37th Companies, R.E., at my disposal for dismantling the bridges. Having made all necessary arrangements for the work, detailing the 17th Company to No. 7 bridge with half our own men, and the 37th Company to No. 8 bridge with the other half, and arranging for bringing up the wagons, I walked up the hill and reported to General Hildyard for orders.

The retirement began soon after 6 p.m., when it got dark, the ammunition wagons crossing first, and was all over by 9 p.m., when, with the help of the 37th Company, the work of dismantling began. There was a moon for the first part of the night, and one could not help feeling a little anxious as to whether the Boers might discover the absence of our troops from the hill and come and practice their marksmanship on us. Two companies of the Devon Regt. remained behind as a covering party, but, being on the south side, they would of course have been powerless to prevent the Boers occupying the other bank. However, the enemy did not take advantage of the opportunity; and by midnight, by which time it had got very dark,

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the bridge (No. 8) was dismantled and the party had started back to camp at Potgieter's Drift. I then rode to No. 7 bridge, but all I could find there was the tail of the rear guard threading its way noiselessly, like a huge dark serpent, along the narrow path. I got close up to the Column (the wagons were leading) before I could hear a sound, and it was too dark to see much. The portion of General Hart's brigade which had been holding Munger's Farm re-crossed by this bridge, which was dismantled and packed with the assistance of the 17th Company. The work here was also completed by about midnight, and both portions of the Troop met at the foot of Zwaartkop, where we were delayed for some hours by an overturned wagon of another unit; we eventually reached our camp at Potgieter's Drift at 5 a.m. Soon after our arrival the Boers planted some of their big shells from Doornkop too close to us to be pleasant, so we hid our wagons among the mimosa bushes.

The retirement of the baggage and stores, of which there was a considerable accumulation at the foot of Spearman's Hill, went on all day on February 8th. It was a very slow process getting the heavy wagons up the steep road to Spearman's Hill; this road was unseen and just out of range from the Boer position, but they amused themselves from time to time by putting shells as close as they could. One of these fell among our horses when they went to water at the Drift; there was, however, no disastrous result except that one of the drivers, who I expect had fallen off in his excitement, but who declared the shell had knocked him off, cut his elbow rather badly.

Between 8 and 9 p.m. Lieut. Skipwith started with twenty-four wagons, with instructions to take them to the Springfield side of Spearman's Hill and to return the next day with the teams and one or two empty wagons.

The retirement of the troops holding the kopjes in front of Potgieter's Drift commenced next day, February 9th, at 10.30 a.m. Elaborate precautions were taken by Sir Charles Warren, who was in command, for the safety of No. 3 bridge during the evacuation of the kopjes. Guns were posted all round and General Coke's brigade occupied good defensive positions. The retirement was very gradual, one company leaving at a time, and was completed by noon, when we commenced dismantling and packing the bridge. A troop of cavalry remained on the kopjes till we had nearly finished and then retired over the Drift. No sooner had they gone than some figures appeared on the crest line of the kopjes and we expected them momentarily to open fire on us; but they turned out to be only some kaffirs from the neighbouring kraals, intent on loot. The bridge (No. 3) was packed by 1.40 p.m.; and we then blew up the pont, and cut its steel wire hawser with charges of guncotton. Thanks to the extra teams with which Skipwith had returned we got up Spearman's Hill without much difficulty and then halted for dinners

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and a two hours' rest. On re-starting again at 6 p.m. the sappers were carried in the wagons as they were a bit played out with all their hard work. This precaution turned out to be most fortunate for the day's work was by no means ended. On reaching Springfield Camp, about 8 p.m., an orderly met me with a message to say the Chief Staff Officer wished to see me. On going to his tent I was ordered to throw a bridge across the Little Tugela at Sand Drift. The river was 40 yards wide, and the bridge was completed by 11 p.m. when we took a well-earned rest.

The troops began crossing at 4 a.m. next day and continued all morning. The bridge was dismantled at 4 p.m.; and we then marched off and joined General Hart's command at Pretorious' Farm near Springfield.

On the following day, Sunday, February 11th, we marched with the remainder of the Force to Chieveley. And so we found ourselves back at our old quarters with another passage of the Tugela in front of us.

PART IV.—PIETER'S HILL.

From the 12th to the 19th February the Pontoon Troop remained at Chieveley. Meanwhile the operations were carried out which resulted in the capture of the Boer positions on Hlangwane and Monte Cristo and of their laagers, and in the retreat of the enemy across the Tugela.

Hlangwane Hill formed the left of the Boer position in the Battle of Colenso. Eastwards of Colenso the country was of a very difficult and rugged nature, without roads, cut up by deep and dangerous dongas, and covered as a rule with thick mimosa scrub. It was an ideal country for Boer tactics, and from the commencement of the campaign it had always been a favourite haunt for the enemy's snipers. East of Hlangwane were Monte Cristo and Cingolo, a commanding range of hills running for about six miles in a south-easterly direction and gradually diminishing in height. Between Hlangwane and Monte Cristo, and about 300 feet below, was a wide scrub-covered plateau, rising and falling in gentle undulations. Running in front of Hlangwane, of this plateau, of Monte Cristo and of Cingolo was a deep, dry donga which ultimately joined the Blaaukrantz River south-east of Cingolo. To the west of Hlangwane the Tugela River made a large bend northwards, running in rear of Hlangwane and Monte Cristo through a deep, rocky gorge and gradually turning south again. On the opposite bank of the Tugela and immediately north of Monte Cristo was Pieter's Hill, which eventually formed the left of the Boer position in the subsequent fighting.

About half-way along its length the high ridge of Monte Cristo and Cingolo was divided by a depression or nek, and south-east of

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this nek the Boers made little preparation for defence. Their new position south of the Tugela consisted of Hlangwane and Monte Cristo (north of the nek) and of the plateau in between. They were separated from their main position in rear of Colenso by the Tugela River, here about 100 yards broad, in places deep, and with a strong current. The two banks of the river were connected, as we afterwards found, by a low bridge ingeniously constructed of railway sleepers and rails strongly anchored down and running from rock to rock in the shallows above the Tugela Falls, a waterfall near Pieter's Hill. Above the bridge was an aerial tramway with substantially-made platforms, connecting on the northern bank with a siding from the Colenso-Ladysmith railway line.* Two large ponts, afterwards found wrecked and partially burnt, were also in use at this point. There was very little in the bridge to get damaged by floods, which as a rule passed over it without injury; the bridge was too narrow (about six feet) and curved too much for use by wagons, but it made a good roadway for horses. Some distance to the east and below Pieter's Hill was a drift, which was, I believe, used by the Boers in their retreat. With the exception of these crossings the river was practically unfordable except at Colenso, though no doubt there were places where men and horses could cross when the river was low. Hlangwane and the southern edge of the plateau below were very strongly fortified with most carefully hidden trenches, the numerous bushes about this part making concealment easy. Monte Cristo was not nearly so strongly held or entrenched and it is improbable that the Boers expected an attack there.

About three miles east of the Chieveley-Colenso railway was Hussar Hill, towards which the ground sloped gently down from Gun Hill at Chieveley, where the heavy Naval guns were posted, rising again gently at the hill itself. Hussar Hill was separated from Hlangwane by numerous dongas and dry watercourses; it was about five miles distant from Chieveley and three from Colenso.

The danger in advancing by Hussar Hill was that we were always liable to a flank attack from Colenso, and the ground was so broken in this direction that it offered great facilities for Boer tactics. Hussar Hill was waterless and all water had to be brought by wagon from the railway tanks at Chieveley camp; all supplies had to come by road. A railway was planned and partially laid out to Hussar Hill during the operations; but it was never completed as, on our occupation of Colenso, the base Depôt was transferred to the railway station there. Hussar Hill was commanded by both Hlangwane and Monte Cristo, but they were both some distance away; it was about

* The Boers had made a deviation from the railway at Modder Spruit, running east of Umbulwhana and joining the main line again near Nelthorpe.

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the same height as the plateau (which I will call Hlangwane Plateau) between these two hills.

After a preliminary reconnaissance the force marched to Hussar Hill on the 14th February and entrenched themselves there, General Hart's brigade remaining at Chieveley to guard the stores and to prevent a counter-attack from Colenso.

From Hussar Hill the Boer trenches on Hlangwane Plateau were systematically shelled, especially at a point called Green Hill, just below the nek on Monte Cristo. The Boer laager could be seen behind this small hill, and it and the sides of Monte Cristo came in for their fair share of shelling, while the Naval guns at Chieveley devoted their attention for the most part to the guns and trenches on Hlangwane itself, distant from them about 8,000 to 9,000 yards. Notwithstanding our occupation of Hussar Hill in strength Boer snipers from time to time crept up the dongas under cover of the scrub, and the crack of the Mauser was frequently heard in the bush close at hand without it being possible to locate the exact position of the firer.

While the bombardment of the Boer trenches was being carried on, General Lyttelton marched his brigade under cover of the hills to the eastern extremity of the Cingolo ridge, and, gradually advancing along it to the nek, drove the Boers before him, the cavalry under Lord Dundonald co-operating on his right flank. He eventually gained possession of the ridge, rendering the plateau below untenable, and the Boers retreated in great haste across the Tugela, their laagers, with stores, ammunition, etc., falling into our hands. In the meantime General Barton's brigade advanced on Hlangwane Hill which it occupied, thus completing the rout of the Boer forces.

On February 20th, at 8.40 a.m., the Pontoon Troop received orders to move to Hussar Hill. After waiting there some little time we were met by a party of Thorneycroft's Mounted Infantry, who informed us they had come as our escort. Soon afterwards a detachment of the Imperial Guides came up, who told us they had instructions to lead us by the nearest way ; they took us straight across country over mealie fields and other cultivation ; it was all our poor oxen could do to get along at all, and in one deep place we broke a pole of one of the pontoon wagons and had to patch it up as best we could. There was a very steep donga at the foot of Hlangwane ; in crossing it two of our wagons turned over and caused considerable delay, and we had some difficulty in getting up the opposite hill. Arriving on top of the plateau about 4 p.m., close to the line of the Boer trenches, our escort and guides differed as to our destination. The officer in charge of the escort said his orders were that we were to go to Blois Farm on our right under Monte Cristo ; the Guides wanted to take us down a shockingly bad road to

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the Headquarter Camp under Hlangwane. As they were not able to come to an agreement I halted at the junction of the two roads and sent both ways for instructions. The Boers were shelling the ridge about a mile in front of us, but we were quite safe where we were. While waiting for definite orders Sir Redvers Buller rode past and told us we could stay where we were for the night, so we formed up just clear of the road.

Our bivouac was immediately in rear of the Boer trenches, and so I got a good opportunity of examining them. They were mostly of the narrow deep type, now known in the service as Boer trenches, made for men to shoot out of standing, and sometimes with head cover and loopholes. They were very skilfully placed, and as a rule well concealed by bushes, natural rock, etc.; and in cases where these did not exist, branches of mimosa had been cut down and stuck in the ground to imitate growing bushes. Some hundred yards in front of the real trench were dummy trenches, made as conspicuous as possible for the purpose of drawing fire, in which they proved very successful. The real trenches were all lined on the top with sacks of earth, to stop ricochets and splinters from stones, whereas the dummy trenches had no such protection. There were evidences on all sides of the hurried retreat of the Boers; tents were left standing, and cooking and other utensils were scattered around; there was a great quantity of ammunition lying about, principally Mauser rifle cartridges, but there were also the paper wrappings in which soft-nosed sporting cartridges had been packed.

Soon after 5 a.m. on the 21st, Sir Redvers Buller rode along and gave me orders to reconnoitre the river for a site for a bridge, the Troop to wait on ready for an advance. Taking Lieut. Skipwith with me I rode forward towards the river. The plateau on which we had bivouacked ended abruptly in a rocky ridge immediately overlooking the river, the rocks being broken up into huge boulders, giving the crest a very wild appearance, and affording good cover to the men of Barton's brigade who were sniping at the enemy on the hills on the north bank. The road or track leading from the plateau crossed a nek below Hlangwane, then turned right-handed to the Boer bridge. On the left of this road the sides of Hlangwane were furrowed by innumerable watercourses, resembling the feelers of a huge octopus and combining in a deep wide donga leading down to the river Descending this donga, which was occupied by picquets of the Royal Welsh Fusiliers, we reached the river and looked about for a good site for the bridge (No. 9). We eventually decided that the donga itself formed the best approach to the river, which was here rather over 100 yards broad. Immediately below the donga the river narrowed down and fell over a ridge of rocks, forming a very pretty waterfall about 20 feet high. On the opposite side the bank had an easy slope, and beyond was a plateau half a mile wide, bordered on

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two sides by low hills, which formed a natural *tête-de-pont* and to a certain extent protected the crossing. To the west, beyond this line of hills, was Grobelaars Kop, rising well above its neighbours; and in a semi-circle, stretching in a north-easterly direction, was a line of hills forming the Boer main position; their right rested on Grobelaars Kop and their left on Terrace and Pieter's Hills, commanding points immediately overlooking the river and about two miles lower down than the donga we had explored. Between the main Boer position and the river were a series of bare rocky kopjes, through which ran the Onderbrook Spruit, all well under fire of their guns and in most cases of their rifles as well.

Retracing our steps along the donga I reported to Sir Redvers Buller, who consented to the site selected. The Pontoon Troop was then ordered up and the 17th and 37th Companies, R.E., were also sent for to make the approaches down the donga.

We got to work at the river at 10.35 a.m. At first the unpacking was very slow as the wagons had to be brought singly down the donga, but soon afterwards the 17th Company arrived and volunteered to help in unloading. The Boers were not long in finding us out, and kept up an intermittent shell fire on us the whole time that the bridge was under construction, without however doing the slightest damage, though several of their shells splashed into the water within ten or fifteen yards of the bridge and one within a few feet of a wagon which the men were unloading at the time. A "heavy" bridge (No. 9) of fourteen three-section pontoons, with three Weldon trestles at the near and two at the far side, was constructed. This made the bridge 100 yards long; but as the bank was found to be very soft two bays were subsequently added, making a total length of 110 yards. The bridge was completed at 1.45 p.m., and our troops, led by the Somerset Light Infantry, at once began to cross; from that time the traffic over it was incessant and went on all through the night. The enemy kept up their shell fire until dark, without doing any other damage, I believe, than wounding a few horses. Our only casualty was a bullock slightly wounded by a bullet when waiting on the top of the nek in the early morning. It was absolutely astounding that so little damage was done; for there was an enormous congestion of traffic on the approaches to the bridge on the south side and a considerable massing of troops of all arms on the plateau beyond the bridge head.

During the whole day of the 22nd a ceaseless stream of traffic poured over the bridge. Wagons and vehicles of all descriptions passed over safely, except for a few minor accidents such as a bullock tumbling over the edge of the bridge or a mule falling into the well of a pontoon. The only serious accident happened to a regimental ammunition cart which fell into the river; when it was hauled out it was found that one of the mules had broken its leg.

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In the morning I rode with the Chief Engineer to see what could be done towards restoring communication over the Colenso road bridge; on the way we passed Fort Wyllie, from which the Boers had poured such a terrible fire at the battle of Colenso. Along the front of this hill ran a deep narrow trench with covered ways round each end; on the back or north side the hill was very steep, and immediately under it was a small laager, absolutely safe from any fire that could be brought to bear on it from the direction of Chieveley. The back of the hill was honeycombed with dug-out shelters, and in some cases the side of the hill had been dug away to admit of a tent being put up. It was said that the Boers only kept one man as sentry in the trenches as long as any shelling was going on, but rushed back into them by the covered ways as soon as our troops came within effective rifle range. The railway bridge was an absolute wreck, every girder and nearly all the piers being destroyed; one span only of the road bridge was broken, and this had been purposely done in December by our Naval guns at Chieveley. Colenso village was a scene of hopeless destruction; every house in the village had been thoroughly looted; partition walls had been broken down, and in the shops the fittings had been removed and sometimes burnt, and all windows and doors destroyed. The houses too had suffered somewhat from our shell fire. Curiously enough the Boers had left the railway station intact, but by way of a grim joke they had dragged a dead horse into the booking office, and the stench was awful. While waiting at the station for replies to telegrams, I visited the spot, about 300 or 400 yards away from the station, where our guns had been taken on the 15th of December; the dried-up carcasses of the horses and the broken harness and equipment bore testimony to the struggle that had taken place.

The Boers shelled the neighbourhood of No. 9 bridge at intervals during the day, but did little damage, which was very extraordinary as the place was crowded with troops and vehicles of all sorts. But our guns were now posted on the hills forming the *tête-de-pont*, and engaged the attention of the enemy, who were thus only able to devote very little time to the bridge. The enemy's guns had been shifted from the centre of their position to commanding points on Grobelaars Kop, which was favourable to the bridge as it could only be very indistinctly seen, and they never placed shells nearer to it than 200 yards all day.

At 6 p.m. an attempt was made to take the 4·7″ guns across the bridge. These guns on their improvised carriages weighed 6½ tons, and as there was only one set of trunnion holes, the weight was unevenly distributed and the bulk of it was thrown on to the front wheels. Although a second layer of chesses was laid lengthways as runners, there was an ominous cracking when the front wheels came into the centre of the first bay; so the rear drag ropes were manned

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and the gun was quickly run back off the bridge before any accident had taken place. Arrangements were made for removing the guns from their "jackets" during the night, thus reducing the weight by rather over 2 tons.

The infantry, who occupied the low hills near the Onderbrook Spruit in front of the Boer position, were exposed all day to a most galling fire from rifles, pom-poms, and artillery, but gallantly kept their ground. At times the fighting was very severe and the casualties heavy, the enemy being able to bring a terrible cross fire to bear from their commanding position on the upper range of hills. There was no cover of any description available, but our troops were able to obtain a certain amount of shelter in hastily constructed sangars on the sides of the hills. Digging trenches was quite out of the question, both on account of the rocky nature of the ground and because any man who exposed himself in the least was at once shot.

At daylight on the 23rd (*i.e.*, about 5 a.m.) the 4·7″ Naval and 5″ R.A. guns with their ammunition were safely passed over the bridge. The Naval guns were taken over in wagons separately from their mountings, but even then the weight was considerable and I breathed a sigh of relief when they were all safely across. With the 5″ guns, weighing 4½ tons, there was not much trouble, as by shifting them from the firing to the travelling trunnion holes the weight was well distributed on the carriage. The traffic on the bridge continued incessantly all day until 10.30 p.m.

At 5 a.m. Lieut. Ommanney left with four "detachments" of sappers for Colenso, in order to erect an aerial tramway across the river there for the purpose of conveying supplies to the troops on the left flank and so relieving the pressure on the bridge. The span of the suspensory cable was 470 feet, and the work was completed by the afternoon of the 24th when the party rejoined. The artillery duel was kept up all day on both sides with undiminished vigour; our objectives were the Boer trenches and sangars on the top of the ridge and their guns on Grobelaars Kop, which were well protected by strong emplacements; while their artillery, besides returning the fire of our guns, distributed their favours pretty generally all round, the bridge coming in for its share. Very little damage, however, was done by the Boer shells.

The infantry maintained their position on the hills; although unable to make much progress, they held their own, and, having improved their sangars, had better cover than on the previous day. In the afternoon General Hart advanced along the river under cover of the railway embankment towards the enemy's left flank; to reach this point he had to cross the Onderbrook Spruit by the railway bridge, on which the Boers brought a very heavy rifle and pom-pom fire, which was the cause of many casualties to the troops crossing. (This bridge, generally called "pom-pom bridge" was sandbagged by

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the 17th Company, R.E., during the following night, thus rendering the crossing less dangerous). On reaching the enemy's left flank, a most gallant attack was made by General Hart's brigade (Royal Inniskilling Fusiliers, Connaught Rangers, and Royal Dublin Fusiliers) on the Boer position; but, although they succeeded in taking and holding the lower slopes and the river bank, they were driven back with heavy loss from the main position on Terrace (or Inniskilling) Hill. In endeavouring to reach these trenches our troops had to cross an open glacis of about 300 yards, on which the Boers were able to bring an appalling fire to bear. The Inniskilling Fusiliers in particular suffered very heavily, especially in officers. After dark a furious rifle fire broke out all along the Boer lines and continued for some time; a counter-attack on our positions, both on our right and left flanks, was attempted, but after heavy fighting the enemy was obliged to retire.

At 4 a.m. on the 24th Lieut. Skipwith left with two "detachments" and a wagon load of sleepers and rails to repair the Boer bridge, so as to allow the passage of supplies to General Hart's brigade. It had been intended that this should be done before daylight as the bridge was under fire from the Boer lines; but unfortunately the wagon broke down and the load had to be transferred to another one, so that he did not arrive until after daylight. Although a fairly hot fire was directed on the bridge, the repairs were completed without casualty, the 37th Company, R.E., assisting in the work from the north bank.

The artillery fire continued all day and musketry fire was also kept up, but no determined attack was made on either side. During the afternoon a heavy thunderstorm raged for about an hour, and the rain, coming down in sheets, soon converted the donga into a roaring torrent and made traffic over the bridge impossible for some time.

About 5 p.m. Lieut.-Col. A. E. Sandbach, R.E., came to me and said he had found a crossing place opposite the Boer left flank under Pieter's Hill and that Sir Redvers Buller wished me to go there with him to see whether it was possible to throw a bridge across. We found a steep path, which after repair would be practicable for wagons, leading down from the end of the Monte Cristo range to the river; part of the path was unseen from the enemy's position and the river itself was quite out of sight. Hart's brigade was bivouacked on the north bank immediately opposite, and with the exception of some snipers among the rocks bordering the river there was no firing going on. We both agreed it was an excellent place for a crossing, as, in addition to being unseen, the river was deep, the current not very strong, and the banks easy. About 200 yards above the point selected, and immediately below the Boer bridge, were the Tugela Falls, over which a considerable volume of water was flowing. Having satisfied ourselves we rode back, Lieut.-Colonel Sandbach to

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report to Sir Redvers and I to the bridge. About 7 p.m. Sir Redvers crossed over to the south bank, and after sending for me told me the 4·7″ and 12-pr. Naval guns, the 5″ R.A. guns, the howitzer battery, and a brigade division of field artillery would re-cross to the south bank at daylight next day. He also questioned me about the proposed crossing near Pieter's. On account of the slippery state of the bridge owing to the recent thunderstorm all traffic over the bridge was stopped at 8 p.m.

At 4 a.m. on the 25th, the 37th Company, R.E., who were required to make the road down at the new site near Pieter's, the howitzer battery, and a brigade division, R.F.A., re-crossed the pontoon bridge from north to south. They were followed by the Naval and the 5″ guns with their ammunition, and all were got across without accident. The ordinary traffic was then resumed. The 17th Company, R.E., also required for road making, re-crossed at 8 a.m. I received orders to make a "pont" at the new site (No. 10), and soon after daylight Lieut. Ommanney went to Colenso station to collect timber (which we had had sent up there), returning with some good loads at 10.30 a.m.

In the meantime an armistice had been agreed upon between the two armies, to bring in the wounded who had fallen in the attack on the evening of the 23rd and to bury the dead. The sufferings of the wounded must have been dreadful during this time, for the Boers fired at anyone who tried to go to their assistance, and they had to be left lying on the exposed hillside in the glaring heat by day and in the cold air by night without either food or shelter. It was Sunday and never was the day of rest more appreciated; after the strain produced by the constant firing and bursting of shells during the past few days, the temporary cessation of hostilities came as a blessed relief to the troops.

Leaving Lieut. Skipwith in charge of No. 9 bridge with a few men, Lieut. Ommanney and I and the remainder of the men moved off at 11 a.m. and reached the top of the road leading down to the river at 1 p.m. The 17th and 37th Companies, R.E., were still working at it and it was not possible to get our wagons down till 4 p.m. In the meantime we spent a most peaceful three hours down by the river. It was a most picturesque spot: on our left the river poured over the Falls with a dull roar and, after rushing wildly among the boulders below, settled down into a broad even-flowing stream at our feet; on either side the hills rose precipitously to a height of about 500 feet, their tops bold and jagged and clearly defined in outline against the deep blue sky; the sides of the gorge were covered with mimosa bushes, still smelling sweetly though the flowering season was nearly over, and with tall growing aloes. It was an ideal spot either for a picnic party or for spending a quiet Sunday afternoon; with us it was a combination of both, for we first

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had our lunch of "bully" beef and biscuit, and then spent the remainder of the time under the shade of the trees reading our letters and looking over the papers which the mail had brought that day. One of the first pictures I saw in an illustrated paper was a very good photograph of the falls we were looking at.

On the arrival of our pontoons, we first put Sir Charles Warren, who had been waiting some time, across to the north bank, and then rowed over the 37th Company, R.E., who were required to make a road up the hill on the opposite side. We then set to work on our pont, which we made of three pontoons (of three sections each) and a decking of timber; and we also constructed trestle ramps as landing places and approaches to them through the scrub. The work was finished at 7 p.m., and after we had some tea the wagons and the greater part of the men were sent up the hill to await us. Lieut. Ommanney and one "detachment" remained to work the pont until the infantry could take it over next day, and I went across the river to see the C.R.E. of the 5th Division, getting back about 9 p.m. We were slowly climbing the hill on the south bank, when, without the slightest warning, a terrific fire broke out from the Boer trenches. It began on the left of their line at Pieter's Hill, but rapidly spread along their whole position. There seemed no reason for it and it was no doubt produced by a scare; as far as I could make out our troops did not reply to it. For a few minutes I and two men with me were in a most unpleasant fix, for we happened to be in the exposed part of the hill where the bullets fell which were aimed at but missed the position held by Hart's brigade. It was a few minutes before we could get under cover, but luckily none of us were hit, though the bullets fell all around us, knocking sparks out of the rocks or burying themselves in the ground with a dull thud. The fire lasted about twenty minutes and then stopped almost as suddenly as it had begun.

We had a fairly quiet day on the 26th, the action being confined almost entirely to an artillery duel. At 4 p.m. I rode to Colenso station to get some more "superstructure" which had been sent up from Maritzburg. No sooner had the unloading of the trucks begun than I received an order to dismantle No. 9 bridge as soon as the Composite Rifle Battalion (details of the King's Royal Rifles and Rifle Brigade) had crossed, and to re-construct it under Pieter's Hill. It was to be ready as soon as possible next day. On getting back to our bivouac Lieut. Skipwith informed me that the Composite Battalion had crossed at 6.30 p.m., but that a message had been received saying supplies for the 2nd Division must be got across before the bridge was dismantled; though we waited two hours for them no supply wagons came near us, so we started work. It was a particularly dark night and I shall never forget the extreme labour it was to get the bridge up the bank and packed on the wagons. It was

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by far the longest bridge we had made (110 yards); each pontoon had three sections, and, besides being rather waterlogged owing to the length of time they had been in the bridge, they had in them two inches of mud which had fallen in from the roadway. They all had to be carried up a fairly steep bank, about 15 to 20 feet high, one section at a time. It was all the men could do to manage this, for they were beginning to feel the effect of their hard work and many of them were much weakened by diarrhœa and exposure. There were forty-two pontoon sections to be hauled up and loaded on the wagons, and also five trestles and twenty-two bays of superstructure, the whole weighing from thirty-five to forty tons. About midnight it looked as if the work never would get finished, the men seemed dead beat and could put no strength into their efforts; but by 2.30 a.m., *i.e.*, after working hard for six hours, we got all the wagons loaded. As there was no great object in secrecy, and as we were too far from the Boer lines for them to see what we were doing, we lit a large bonfire with broken material and this helped us considerably in our work.

After giving the men some tea, we started at 3 a.m. for Hlangwane Nek, which we reached in three-quarters of an hour. There an issue of rum was made; and, as there was some doubt as to our proper direction owing to the darkness and the innumerable tracks that went in all directions, we made a halt and the men got a short sleep. I went forward with one of the sergeants to try and find the way; but after tumbling over huge boulders for some time, we gave it up as hopeless and waited for daylight. About 5 a.m. we moved on, reaching the river below Pieter's Hill soon after 6 a.m. A "heavy" bridge (No. 10), 95 yards long, of sixteen bays of pontoons with a trestle at each end, was then put in; it was completed before 9 a.m. The men worked very well, the short sleep they got on the top of the hill having quite refreshed them. We felt so certain that we were nearing the goal for which the Natal Army had been striving so long that Lieut. Ommanney asked me if he might put up a signpost pointing out the way; on the end of a boat-hook he nailed a piece of wood on which was painted "To Ladysmith" and a finger pointing in the direction, and erected it at the tail of the bridge. This sign-board caused a good deal of amusement among the troops as they advanced to the attack.

The south bank, rising as it did almost perpendicularly from the river below, gave us a magnificent artillery position; and here all our guns, both Naval and R.A., were massed, and were able to bring a terrible concentrated fire on to the Boer trenches on Terrace, Railway, and Pieter's Hills at a comparatively short range. The maxim guns were also massed on the edge of the cliff, distributed among the huge boulders and peaks of rock, whence from under good cover they could pour a murderous fire on to the opposite hills.

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Seen from below, the hill had the appearance of a mediæval castle hewn by Nature out of the solid rock.

Soon after 9.30 a.m. General Barton's brigade crossed No. 10 bridge, and crept down the river bank for rather over a mile, when they turned left-handed and scaled the steep sides of Pieter's Hill. They were followed by General Kitchener's brigade [General Kitchener had taken over the command of General Wynne's brigade on the latter being wounded a few days before] and by the 4th Brigade under Colonel Norcott. General Hart held the hill in front, covering the bridge. The attacking force was under the command of Sir Charles Warren. A deep and precipitous ravine, along one side of which runs the Colenso-Ladysmith railway, separated Pieter's Hill from the main Boer position on Terrace and Railway Hills. The latter in particular was a most formidable place to attack, the slopes being free from cover and very rough, and the enemy being most strongly entrenched in successive lines of deep works.

Between 9.30 a.m. and 10 a.m. our maxims opened a heavy fire on the Boer trenches at a range of under 2,000 yds.; and the sharp crack of their discharge, coming from among the boulders where they were hidden, gave the impression of a ceaseless infantry fire. Soon the artillery joined in, and from then on there was a continuous roar of gun and maxim fire which was quite deafening to us in the river-bed below. This fire, murderous as it seemed, was probably not very deadly, as the Boers were well hidden in their narrow deep trenches; but it made them keep their heads down, and prevented them from offering as strong an opposition to the infantry as they would otherwise have done. Under cover of the artillery fire the infantry scaled the steep sides of the boulder-covered hills and rushed the Boer trenches in the most gallant manner, capturing the main position about 4 p.m. Firing then stopped for the day; but it was anticipated that it would recommence on the morrow, as the enemy still held a ridge of hills beyond.

Our casualties were heavy, but the Boers also lost considerably, and we took about forty prisoners, who were brought down about 5 p.m. and taken across the bridge; a motley crew they were, care-worn looking and ragged, many of them with their clothes and faces discoloured by the yellow fumes of our lyddite shells; though the majority looked depressed, some seemed distinctly pleased at finding themselves safe in our hands. One of the wounded Boer officers, better educated than his companions, told our medical officer who was attending to him that his men, when they saw the British soldiers rushing on them with the bayonet, began to cry and said they would be killed; but he reassured them and told them that the British were a more civilised nation than they themselves were, and that if they surrendered they would only be made prisoners. It was probably this incident that an eye-witness on the south bank of the

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Tugela told me he saw. He said he watched our infantry come up the hill, being fired on the whole time, and then fix bayonets and charge; when they got near the trenches, the Boers, who had been firing all the time, suddenly threw down their arms and held up their hands; our infantry officers rushed quickly to the front, stopped the charge, shouldered arms, and walking forward quietly took the Boers prisoners; it was a brilliant example of good discipline, and of the influence of the officers over their men at a moment of extreme excitement. Two men of the Pontoon Troop were wounded during the afternoon, when sitting on the river bank under what seemed perfect cover.

It was a splendid exploit taking this strong Boer position, where one fire-crowned ridge rose above the other, where the ground was intersected by unexpected dongas, and where the hills themselves, steep and difficult to climb, were covered with rough boulders and with rocks carved by nature into strange fantastic shapes. The enemy certainly deemed the hill impregnable, and indeed it looked to be so. Coming as it did on the day after the anniversary of Majuba, the victory was a welcome one for us, and we were doubly elated by hearing in the morning, just before the battle began, of the surrender of General Cronje at Paardeberg.

Early in the morning of February 28th it was found that the Boers had evacuated that portion of their position which they were holding on the previous night. They still occupied some kopjes near Pieter's station, and our cavalry, crossing the plain in front of them, had to approach with caution. The field guns and howitzers were brought over the ridge early in the day, and placed in position on the top of the ridge overlooking the plain between Pieter's Hill and Umbulwhana; and later these guns were followed by the Naval 4·7″ and 12-prs.

During the morning I rode round the Boer trenches and was much impressed with the strength of the position. Tier rose upon tier of narrow deep trenches, round which the explosion of the lyddite shells had made deep pits and covered the surrounding boulders with their yellow fumes. The trenches were full of ammunition, principally Mauser, of which there was a very large quantity; the bullets had all been dipped in grease and had turned bright green, which gave rise to the report that the cartridges had been poisoned. There were also numerous empty wrappers of packets of soft-nosed cartridges, Martini-Henri ammunition, and also some Lee-Metford cartridges. A number of Boer rifles were found lying about, and were collected and broken; many of them were fancifully carved on the stock with the names of the owners and of the different battles in which they had been engaged; on one that I saw the stock was carved "J. L. Kruger, 1899," the name, I believe, of one of President Kruger's grandsons who was killed in the fight.

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The melancholy task of collecting and burying the dead was going on. Our own men were buried in regimental graves, and the Boer dead were collected together in suitable spots and buried where convenient. All the Boers who had been killed or wounded in the early part of the fight had been removed from the hill by their own people and sent off by train; those that we found there were probably killed in the final attack.

The day was spent in bringing the baggage and stores to the north bank of the river; and the cavalry, feeling their way cautiously, pushed on to Ladysmith, which they reached in the evening.

Early on the 1st of March the infantry advanced towards Ladysmith and encamped at Nelthorpe. Getting leave from General Hart, whose brigade was left to protect the bridge head, I rode into Ladysmith. Near Nelthorpe the drift over the Klip River was rather dangerous and the only means of advancing was along the railway line. The swollen state of the river did not however prevent our troops at Nelthorpe from fording it and paying a visit to the deserted Boer camp on the nek below Umbulwhana; here the tents remained standing, showing the haste with which the Boers had left, and our men returned laden with blankets and with a few eatables that were much appreciated after the constant menu of "bully" beef and biscuit which had been their fare for the last few weeks.

Below Umbulwhana, one passed that monument of Boer folly, the dam across the Klip River. It was then about half completed, and as the rainy season was coming to an end the Boers could not have hoped for any result from it until the summer (our winter) of 1900–01. The dam was designed to flood out the town of Ladysmith and render our position there untenable, and the commencement of such a work shows the confidence the enemy had in their power to maintain the siege and to prevent the relief force from succouring the garrison. Everywhere were signs that work on the dam had been continued until the last moment. The dam was made of sacks of earth built across the river; it was about 100 feet thick and 50 feet high, and had sluices to let the flood water escape during construction. On the banks were hundreds of picks and shovels, and sacks, some filled and loaded on to trucks, others abandoned with only a few shovelsful of earth in them; and there were also the deserted encampments of natives who had formed the working party on the dam. These camps were well stocked with mealie meal, and showed unmistakable signs of recent occupation and hasty evacuation.

The first of the Ladysmith garrison whom I met was a brother officer, Lieut. A. B. R. Hildebrand, who was working near the dam, repairing the telegraph line to Colenso. He was very well and cheery, and asked me to go and stay with the Telegraph Battalion in Ladysmith. The Telegraph detachment with the Relief Column was repairing the line from the south, and by working on until the two

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parties met, telegraphic communication between Ladysmith and the outside world was re-established in the evening. Pushing on past the Intombi Hospital, where so many of the brave defenders of the town spent their last few days on earth, I reached Ladysmith.

What struck one most on entering was the paucity of outward signs of the bombardment; here and there the end of a house was blown in or a wall knocked down, but there was none of the general ruin which one would expect to see in a town that had withstood a four months' siege. This was accounted for by the houses being well scattered, mostly in small gardens of their own, and being chiefly built of corrugated iron, which offered little resistance to a shell. The Town Hall seemed to have suffered most; there were one or two large holes in the walls of the building, and a large portion of the tower had been shot away. Some of the shops, more especially those of the dry goods merchants, were still open; but in all those where eatables of any description were usually sold there was an entire absence of stock in hand, and this told its own tale. The most striking signs of the siege were the pale, emaciated, fever-haunted looks of the garrison and of the townspeople, and the lack of interest they seemed to take in life. What also struck one was the clean trim appearance of both officers and men, forming a great contrast to the Relief Force, the greater part of whom, both officers and men, had been unable even to wash during the past fortnight and whose clothes in many cases were in rags. The cavalry and artillery horses of the garrison, at least those which had not been converted into "Chevreuil," were in a pitiful condition and were mere walking skeletons.

I spent a very pleasant evening with the officers of the Telegraph Battalion, R.E., hearing their experiences and recounting my own. They were very grateful for a few tins of potted meat, chocolate, etc., which I had brought up in my wallets; and in return they shared with me their frugal repast of trek ox (or horse, it was just as well not to enquire too closely) and mealie meal porridge, a dish which I did not altogether appreciate though they seemed to relish it immensely. It was pathetic to see the care with which they measured out the portions of food, and each one produced his little tin of sugar, etc. The reason for each having his private supply was, they explained, that one might like his sugar with his tea and another with his porridge, and, as there was not enough for both, by having individual stores each one could please himself. They told me of one mess where the senior officer, who either had a grand disregard for the shortness of siege fare or was of a particularly absent-minded disposition, being served first, invariably helped himself to three rations of sugar, leaving the poor juniors to fare very badly in consequence.

The following day I spent visiting friends, one of whom, wounded at Talana Hill, was still in hospital at Intombi, and in going round the

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fortifications. It was difficult at first to understand how such an apparently indefensible place could possibly stand a siege where the enemy really meant business; but after a closer inspection one realised that the circle of low hills surrounding the town on three sides, when well entrenched and covered with walls and sangars as they were, offered a strong barrier to an attacking force. The east side of the town was the least defensible, for here there was no protecting ring of hills but an open plain, bounded on the east and north-east by the commanding points of Umbulwhana, Gun Hill, and Lombard's Kop, on the two former of which the Boers had heavy guns. Had the enemy on the 6th January succeeded in taking Cæsar's Camp and Wagon Hill, there would have been little hope of the garrison holding out.

The Relief Force marched into Ladysmith at 10 a.m. on the 3rd March. The Ladysmith Garrison lined both sides of the main road through the town from the railway station to the prison, where some Boers were still in custody. As the Headquarter Staff approached each company of the garrison presented arms and then gave "three cheers for General Sir Redvers Buller and the Relief Force." Sir George White and his Staff were drawn up opposite the Town Hall. Besides the garrison there were small groups of townspeople, who did their best to become enthusiastic; but all, both soldiers and civilians, looked worn out and tired from their recent experiences. Each regiment as it approached was cheered by the garrison and cheered back in return. It occupied about half an hour for the head of the column to march through the streets. On arrival on the plain between the town and the "Tin Camp" Sir Redvers Buller fell out, and the Relief Force continued their march past him, each regiment cheering him heartily as it passed. A splendid body of men they looked, bronzed and hardened by their recent efforts and by exposure to the almost tropical sun, their dirty and worn-out clothes in no way detracting from their fine appearance. How little did one think, as one watched these brave men march through the streets, proud in the knowledge of duty well done, that in a few short weeks enteric fever, the terrible scourge which had already worked such havoc among the defenders of the town, would make such a heavy claim on them and would number so many of them among its victims. Before the Relief Force continued its march northwards, the numerous graves in the Ladysmith cemetery and in the new burial enclosures on the bare hillsides marked the last resting place of many a one now full of life and vigour.

In the afternoon I rode back to Pieter's Hill, paying the "Long Tom" emplacement on Umbulwhana Hill a visit on the way. It was a stiff climb to get up to it. The emplacement was well protected with barbed wire, and besides the ammunition left behind there was a good supply of hand grenades, showing that after their experiences at Gun and Surprise Hills the Boers did not feel too secure against an

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attack. From there, after a terrible scramble over huge boulders, I passed through the Boer camp; like all others I came across in the campaign, it was in a horribly dirty condition and littered about with old clothing, rugs, tin boxes, and all sorts of odds and ends, including torn hymn books and bibles, children's lesson books, and English illustrated papers and novels.

Arriving at the river at 7 p.m. I found my subalterns just finishing packing up No. 10 bridge. We moved a little way from the river and bivouacked, but did not have a very pleasant night, for the most horrible smells were wafted to us from all sides. Next day we marched back to Colenso; and on the following day, March 5th, moved by the main road over Grobelaars Kop to Ladysmith, where we remained for the next two months.

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MEMOIR.

MAJOR-GENERAL SIR CHARLES W. WILSON, K.C.B., K.C.M.G., F.R.S.

CHARLES WILLIAM WILSON was born at Liverpool on March 14th, 1836. He was the second son of Edward Wilson, Esq., J.P., of Hean Castle, Pembrokeshire. He was educated at St. David's, Liverpool College, Cheltenham College, and the University of Bonn. At an open competition for admission to the Corps of Royal Engineers in 1855 he obtained the second place, and was gazetted to the rank of Lieutenant on September 24th in the same year. After going through the course of instruction at the Royal Engineer Establishment, Chatham, of which Colonel H. Sandham, R.E., was then Director, he was posted for duty to Shorncliffe Camp in 1857. After five months at Shorncliffe Wilson was placed under orders for India and returned to Chatham for a short time, when the orders were cancelled and he was sent to Portsmouth.

Even at this early stage in his career he gave evidence of the capabilities which distinguished him through life, and early in 1858 was selected as Secretary of the Commission, which was appointed to delimitate the portion of the boundary between Canada and the United States, comprised between the Pacific Ocean and the Rocky Mountains. The settlement of this boundary, extending over nearly sixty degrees of longitude, has been a long and difficult operation. The work commenced shortly after the Treaty of 1773 had been made and was only completed in 1874, several Commissions having from time to time been engaged upon the work. Prior to 1858 the eastern portion from the Atlantic to the Lake of the Woods in Longitude 95° had been settled but nothing had been done westward of this point. The territory on the Pacific side was becoming more or less populated, and it became an urgent question to fix the frontier. It was with this object that the Commission was arranged to which Wilson was attached. Colonel Hawkins, R.E., was nominated as British Commissioner, and the work commenced in August, 1858, and was continued until 1863. The line of demarcation commenced at the Gulf of Georgia, opposite Vancouver Island, and was continued along the 49° parallel to the summit of the Rocky Mountains. The country passed through was very difficult, swampy in the western parts and then thickly wooded and very rugged. Little dependence could be

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placed on the resources of the country and food and forage had to be brought from a considerable distance. Lieut. Wilson had charge of the interior economy of the Expedition, the transport and commissariat arrangements, and, for some time, of the survey operations. The manner in which he carried out his very arduous duties proved the selection was an excellent one, and, at the close of the work in 1863, he received the thanks of the Secretary of State for Foreign Affairs for the assistance that he had rendered to the operations of the Commission.

On his return from North America, Wilson was employed upon Defence Work at Chatham until August, 1864, and then undertook a duty which greatly affected his future career. At that time Miss Burdett-Coutts (now Baroness Burdett-Coutts) was much interested in the question of providing a good water supply for the City of Jerusalem. She was advised by a Committee, of which the late Dean Stanley was a prominent member, that, before the question could be properly discussed, it was quite necessary to have an accurate survey made of the town and surrounding country. Dean Stanley applied to the Secretary of State for War, who placed the matter in the hands of General Sir Henry James, Director-General of the Ordnance Survey. The conditions were that the sum of £500 was to cover *all* expenses. It was settled that an officer of the Royal Engineers would be allowed to do the work on the understanding that he received no extra pay whilst so employed and paid all his own expenses. The appointment was offered to several officers, who, not unnaturally, declined it. Wilson heard of the proposal, and at once wrote to Sir H. James, to say he was willing to do the work on the conditions proposed. Some of his friends thought he was foolish and that he would not succeed in carrying out the work. But the result proved the correctness of his judgment. He proceeded to Jerusalem in August, 1864, and completed the survey in rather less than a year, having expended only a few pounds more than the original estimate. The work included not only the survey of the town and surrounding country, but also plans of the Haram Area, held so sacred by the Mahomedans, and a series of levels from the Mediterranean to the Dead Sea. Besides Wilson, the party consisted of Sergeant Macdonald, R.E., and four sappers, and so admirably did all work that by the time they left Jerusalem the Royal Engineers were looked upon as people who could be allowed to go anywhere and do anything. The plans and reports were published by the Ordnance Survey at Southampton, and remain, up to the present, the standard work on Jerusalem as it now exists.

Wilson had been promoted to the rank of 2nd captain on 20th June, 1864, and on his return to England, proceeded to the Ordnance Survey. He did not, however, remain long at Southampton, but returned to Palestine in November, 1865, to take charge of an expedition for the Palestine Exploration Fund. This Fund was

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established in June, 1865, by a Committee of which Dr. Thompson, the Archbishop of York, was chairman, and Dean Stanley one of the leading members, for "the prosecution of systematic and scientific research in all the branches of inquiry connected with the Holy Land." The principles upon which the work was to be undertaken, and which have been rigidly adhered to for forty years, were :—

1. That whatever was undertaken should be carried out on scientific principles.
2. That the Society should, as a body, abstain from controversy.
3. That it should not be started, nor should it be conducted, as a religious society.

There can be no doubt but that Wilson's great success in the conduct of the survey of Jerusalem was a prominent factor in the original starting of the Society, and, it is not too much to say, that he has been its mainstay up to the time of his death. His loss to the Society is irreparable. It was natural that the Committee should have looked to him from the commencement and that he went out as their first explorer. He proceeded to Palestine, accompanied by Lieut. S. Anderson, R.E., and carried out a preliminary survey over a great part of the country. The latitudes and longitudes of a number of points were fixed, a line of azimuths was carried from Banias to Jerusalem, and many plans and drawings of ancient sites and buildings were made. This reconnaissance may be regarded as the starting point of the vast amount of survey work and archæological researches, which have been carried out by the Palestine Exploration Fund. Wilson was elected as a Member of the executive committee of the Fund on his return to England.

After the completion of his work in Palestine, Wilson was appointed to the Ordnance Survey of Scotland and was stationed at Inverness from 1866 to 1868. On January 22nd, 1867, he married Olivia, daughter of Colonel Adam Duffin, of the 2nd Bengal Cavalry. He acted as Assistant Commissioner on the Borough Boundary Commission of 1867. In October, 1868, he undertook the Survey of the Peninsula of Sinai, the expenses of which were met by public subscription. As the amount of money raised was scarcely adequate to meet the cost of the survey, Wilson agreed to go out on the same terms as those he had accepted when engaged on the survey of Jerusalem. The maps and reports were published by the Ordnance Survey, and contain a mass of useful information respecting Mount Sinai and the surrounding districts. The survey was completed in May, 1869, when Wilson was ordered to the War Office as Executive Officer in the Topographical Department, of which he was appointed Director in the following year. In 1869 he was elected a Fellow of the Royal Geographical Society and selected as official Member of Council of the Royal United Service Institution.

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In 1871 the Topographical Department was expanded into the Intelligence Department, of which General Sir P. Macdougall, K.C.B., was appointed Chief with the rank of Deputy Adjutant-General, and Wilson continued as Executive Officer of the Topographical Branch, ranking as Assistant Quartermaster-General, until March, 1876. He received the civil C.B. in the following year for the services he had rendered in the formation and organization of the Intelligence Department, of which he may be regarded as the founder. He was promoted Major, Royal Engineers, on May 23rd, 1873.

During the period spent at the War Office he continued his work in connection with geography and exploration. He received the Diploma of the International Geographical Congress at Antwerp in 1871, for the Jerusalem Survey, and was elected Member of Council of the Royal Geographical Society and of the Society of Biblical Archæology in 1872. In 1874 he received the distinguished honour of being made a Fellow of the Royal Society for his work in Jerusalem, Palestine and Sinai, and was President of the Geographical Section of the British Association the same year.

After leaving the War Office, he was specially employed at the India Office on the compilation of a map of Affghanistan, and received the thanks of the Secretary of State for India for the manner in which the work was carried out. On the completion of this duty he was appointed to the command of the Ordnance Survey in Ireland, and held the appointment until March, 1879. During the period of his service on the Ordnance Survey, Wilson was selected in 1878 as British Commissioner for the delimitation of the Boundary of Servia in accordance with the International arrangement under the Treaty of Berlin. For this duty he received the thanks of the Government, and was promoted Brevet Lieutenant-Colonel on April 19th, 1879.

Shortly after returning to the Ordnance Survey at Dublin he was chosen for a very important position in the East. This was the appointment of Consul-General for Anatolia which he held from April, 1879, until August, 1882. His duties necessitated constant travelling through Asia Minor, frequently under difficult conditions, and, while carrying on his official work, he was able to collect a great deal of valuable geographical information, of which much is available for the public in the handbook for Asia Minor and Constantinople, which he edited for Messrs. Murray some years afterwards. During the period of service in Anatolia, Wilson was employed on a special mission by the Foreign Office to Bulgaria, Roumelia and Macedonia, and also on a tour of inspection of the Consular posts in Asia Minor, Syria, and Palestine. He received the thanks of the Government for his services, and was created K.C.M.G. in 1881. During the same year he became regimental Lieutenant-Colonel in the Corps of Royal Engineers.

In 1882 the political trouble in Egypt was ended by the successful

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campaign of General Sir G. Wolseley against the army of Arabi. It was recognized that the services of Sir C. Wilson, from his intimate knowledge of the East, would be of the greatest value, and he was ordered to proceed from Asia Minor to Egypt and to be attached for duty to Sir Edward Malet, the Consul-General. He arrived in Egypt during the campaign, for which he received the medal and Egyptian star, and reached Cairo shortly after its occupation by the British troops, where his first duty was to see that the safety of the Museum of Antiquities at Boulac, and of the Public Library were secured. He was then ordered to look after the Egyptian political prisoners, to inspect the prisons, and see that justice was done. He was next appointed on behalf of the British Government to watch the trial of Arabi and his associates; and to him it was greatly due that the affair, which presented great difficulties, was brought to a satisfactory conclusion. Wilson received the thanks of the British Government for the services he had rendered and was promoted Brevet Colonel on April 19th, 1883. In addition to the work under the Consul-General, he was attached to the staff of Lord Dufferin, who was sent on a special mission in connection with the re-organization of Egypt. On the completion of his duties in Egypt, Wilson returned to Dublin and again took up the charge of the Ordnance Survey.

During the period when he was in Egypt, Sir C. Wilson had devoted much attention to the state of affairs in the Soudan where the rebellion against Egyptian authority, which had commenced in 1881, was gradually spreading. In September, 1882, he made a Report to Sir E. Malet on the condition of the country and strongly recommended that two British officers should be sent to Khartoum to report on the steps that would be necessary to ensure pacification. The proposal was approved by the British Government and Lieut.-Colonel Stewart was ordered to proceed to the Soudan, respecting which he forwarded an interesting Report in February, 1883, and pointed out the measures which should be taken for improving the condition of the country. Unfortunately the British Government failed to realize the intimate connection between Egypt and the Soudan, and disclaimed any responsibility for the latter. This is not the place to discuss the Soudan question. Suffice it to say that the rebellion spread rapidly and that early in 1884 General C. Gordon was sent to Khartoum to report on the condition of affairs and to withdraw the Egyptian troops. His task proved to be an impossible one and he was besieged in Khartoum by the rebel forces. At last England woke up to the situation and an expedition was despatched up the Nile. But it was then too late and Khartoum fell before it could be relieved. Sir C. Wilson was selected as Chief of the Intelligence Department with Lord Wolseley's force and proceeded to Egypt in September, 1884, with the rank of Deputy Adjutant and Quarter-master-General. Lord Wolseley arrived at Korti on December 16th,

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1884. The scanty information which was received from General Gordon showed that Khartoum was in a desperate condition. On December 30th Colonel Sir Herbert Stewart was ordered to proceed across the desert towards Metemmeh in command of the Camel Corps and halted at Gakdul where he formed a depôt and returned to Korti for reinforcements. He started again for Gakdul on January 8th, 1885, and Sir C. Wilson accompanied him with orders to see General Gordon in Khartoum, if possible, and to inform him that a British force was approaching to relieve him. Stewart's force started from Gakdul for Metemmeh on January 14th and after a severe action at Abu Klea, and further fighting, in which Stewart was severely wounded, arrived on the banks of the Nile on January 19th. Stewart being incapacitated, the command of the force devolved on Sir C. Wilson. The village of Gubat was occupied and placed in a state of defence on the following day and steps taken to secure the safety of the small British force, which was in a hazardous position, surrounded by thousands of the enemy. On January 21st the steamers, which Gordon had sent down in September to meet the British troops, came up and reported that they had been waiting for the arrival of the latter. Gordon had sent these steamers as he believed that the British force should arrive at the Nile in October, and they had been cruising up and down the river, constantly fighting with the rebels for four months.

Captain Lord C. Beresford, R.N., who had been sent by Lord Wolseley to take command of the steamers, prepared them as quickly as possible for the journey up to Khartoum, and they were ready to start by the morning of January 24th. In accordance with his instructions, Wilson proceeded to Khartoum leaving Colonel Boscawen in military command at Gubat. He took two steamers, *i.e.*, the "*Bordein*" and the "*Tell Hoween.*" The Nile was low and travelling was in consequence very difficult. In ordinary times, steamers would not have attempted to pass the sixth cataract at that period of the year. It took four days to go up the river and on arriving near Khartoum on January 28th it was found that the place had fallen and Gordon had been killed on the 26th.

It will be remembered that, at the time, an attempt was made in the press to throw upon Wilson the blame of arriving too late and being therefore responsible for the failure of the expedition. But a more unjustifiable accusation was never made. The expedition failed because it started too late, and Wilson was not sent to relieve Khartoum but to let Gordon know that the British force would arrive some time later. His orders were most distinct. The important portion of them was as follows :—

"As soon as Lord C. Beresford reports that he is ready to proceed with one or more steamers to Khartoum, you will go to that place with him and deliver the enclosed letter to General Gordon, I leave it open so that you may read it.

"Orders have been given to Sir H. Stewart to send a small detach-

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ment of infantry with you to Khartoum. If you like, you can, upon arriving there, march these soldiers through the town, to show the people that British troops are near at hand. If there is any epidemic in the town you will not do this. I do not wish them to sleep in the city. They must return with you to Metemmeh. You will only stay in Khartoum long enough to confer fully with General Gordon. Having done so you will return with Lord C. Beresford in steamers to Metemmeh."

It is matter for thankfulness that Khartoum had fallen before Wilson reached it. Imagine what Gordon would have felt had Wilson met him in the midst of the starving people and given him the message. "I am not sent to help you and cannot stop with you, but there will probably be a British force to relieve you in about six weeks."

On the return journey from Khartoum to Metemmeh both steamers were wrecked, and Wilson and his party had to remain on Mernat Island until taken off by Beresford who came to their relief in the "*Safieh.*" Wilson left Gubat on February 6th and arrived at Korti on the 9th. Lord Wolseley immediately telegraphed to the War Office an account of the journey to Khartoum, and the Secretary of State for War replied—"Express warm recognition of Government of brilliant services of Sir C. Wilson, and satisfaction at gallant rescue of party." On the conclusion of the campaign, Wilson returned to the command of the Ordnance Survey in Ireland in June, 1885. For his distinguished service in the Soudan he was mentioned in despatches (see *London Gazette*, August 25th, 1885) and was created K.C.B.

Wilson remained in Dublin until November, 1886, and was then nominated as Director-General of the Ordnance Survey, an appointment which he held until March, 1894. He was promoted Temporary Major-General on February 22nd, 1893, and Major-General on February 15th, 1894. The civil distinctions which he received in the years under review were as follows:—Hon. D.C.L., Oxford University, 1883; Hon. LL.D., Edinburgh University, 1886; Member of Council, Royal Geographical Society, 1887—1890; President of the Geographical Section of the British Association, 1888; Member of Council of the Royal Society, 1889—1890; Hon. M.E., Dublin University, 1893.

The moment when Wilson became Director-General was important in the history of the Ordnance Survey as the work to be undertaken in the future was not definitely fixed, and there was a probability that the staff would be considerably reduced notwithstanding the large and important work that remained to be done. He obtained authority for the revision of the Irish Survey on the $\frac{1}{2500}$ scale, and commenced the survey of Lancashire and Yorkshire on the same scale. He succeeded in commencing the revision of the small scale maps, which had practically been left unaltered for many years,

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and in initiating a system for bringing them up to date. He also devoted much attention to the organization of Survey Sections for employment with an army in the field, and the result has been that the Military Topographers trained by the Ordnance Survey have done excellent work in South Africa and the British Colonies. It is really difficult to speak in sufficiently high terms of the improvements which he introduced, working, as he always worked, in a quiet way but ever advancing in the direction of real efficiency and for the advantage of the public service.

After his period of service on the Ordnance Survey, for which he had done so much, came to an end, he was unemployed for nearly a year and was then appointed, on January 22nd, 1895, as Director-General of Military Education at the War Office, a position which he held until retired, under the age clause of the Royal Warrant, at 62 years of age on March 13th, 1898.

But although retired from professional life, his interests in the subjects of geography and exploration continued unabated. He devoted much attention to the work of the Palestine Exploration Fund and supervised the excavations by visits to the Holy Land. In 1901 he was unanimously elected Chairman of the Executive Committee of the Society in succession to Mr. James Glaisher, F.R.S., who had occupied the position for twenty years. The Society owes a great debt of gratitude to Sir Charles Wilson not only for the constant care and attention which he devoted to the work, but for the very valuable papers that he contributed to the Quarterly Statement. Of these perhaps the most important was a series of articles on the Holy Sepulchre at Jerusalem. He had intended to publish these in book form, and was engaged upon this up to the time of his death. The Committee of the Fund have decided to complete the publication, and it will undoubtedly be the standard work upon the subject.

Sir Charles Wilson died at Tunbridge Wells on October 25th, 1905, after a few months' illness. His funeral, which was at Tunbridge Wells, was attended by representatives from the War Office, the Royal Geographical Society and the Palestine Exploration Fund, besides many personal friends. His loss to those who knew him well leaves a gap that nothing can fill.

C. M. WATSON.

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TRANSCRIPTS.

LESSONS OF THE RUSSO-JAPANESE WAR.

IV. Engineers.*

Since the days of Todleben, Russia has always been strong in Engineers. The defences of Port Arthur were of vast strength, and the temporary works thrown up around them of scarcely less importance than the scarped castles on the limestone rock behind them.

During the battle of Liaoyang, Kouropatkin caused a huge *tête du pont* of semi-permanent works to be constructed on the west or left of the position. *La France Militaire* holds that this combination of works was of great strategical value as it enabled the Russian Generalissimo to use two army corps only, protected by these works, to watch Generals Nodzu and Oku, whilst he concentrated the rest of his forces on the north-east of the town to face the enveloping movement of Kuroki. The works erected to the south of Liaoyang, under the superintendence of Colonels Jdanof and Vinovski, deserve more than passing mention. The credit of their construction belongs to the East Siberian Sapper battalions. Of these the 2nd were taken prisoners at Port Arthur, and the 1st elsewhere employed, so the 3rd and 4th are the units that probably did most of the work. The profiles were strong, and constructed so as to give the greatest possible development to front, or direct, rifle fire. In the interior slopes were placed barrels, sunk in the earth, constantly filled with rifle ammunition. This idea, borrowed from the Turks at Plevna, enabled the infantry lining the parapets to pour a continuous and intense rifle fire on the glacis and all the ground in front of the works, without having to trouble itself about the difficulties of supply of ammunition under fire. This matter, as all infantry officers know only too well, is a difficult one, and its successful arrangement by the Turks and Russians is to be noted. In the angles, or *pans coupés*, of the works, which resembled blunt lunettes, were placed quick-firing guns mounted *en barbette*, so as to command an all-round fire. These guns could be easily run down under cover by the ramps of approach. Under these ramps and the whole parapets, with twelve to eighteen feet of earth cover, were the shelters, in which the garrisons of the works slept, fed, and passed their few leisure hours. These retreats were approached by steps; the width of the entrance being small the danger from shell-bursts was reduced to a minimum. Outside and all round the works was a complete barrier of wire entanglements

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and *trous de loup*, or pits provided with sharp stakes. These obstacles were directly under the fire, not only of the infantry, whose rifles lay on the superior slope, but of the quick firing-guns in the angles of the works before described. Owing to the configuration of the ground it was not possible to give these works all the necessary advantages of site. Many of them were commanded by hills to the south, and from 4,000 to 6,000 yards from them. As these were in the occupation of the Japanese they mounted heavy guns there that they had used at Port Arthur. But the results of the bombardment from this heavy artillery were but meagre. Brought up at such labour it failed either to breach the works, to subdue their fire, or to cause serious casualties in the ranks of the defenders. The Japanese found it necessary, as we have already expressed our opinion it will be, to call in the aid of the field artillery. The direct defensive rifle fire and the mutual flanking fire of the works rendered nugatory all the Japanese efforts to take them by infantry assault. The attackers lost enormously, whilst the garrisons of the forts suffered little, their total casualty list amounting to only 300. Not one of these semi-permanent works was taken. When the retreat commenced, and the ground between them was vacated, the fire of the forts still denied it to the enemy. The works themselves were only vacated on the 3rd September at 6 a.m., by the order of the General Commanding-in-Chief.

It will appear from this description, drawn it is true from Russian sources, that it is almost impossible to dislodge good troops from strong semi-permanent works. All the attacks on Bilderling's army on the Shaho position, near Mukden, were repulsed, as well as those above described. Yet these attacks were made by excellent troops, supported by a powerful artillery, including guns of 28-centimètres, say 11-in., calibre. The effects of the bombardment were not sufficient to force the infantry out of its underground shelters, and at the moment of assault its fire, like that of the Turks at Plevna, recovered its full intensity, when the fire of the attacking guns was suspended for fear of killing their own infantry. Whilst we are willing to give full belief to the assurances of the *Russki Invalid* as to the tactical supremacy conferred by semi-permanent works, there is another, the strategical, aspect to be considered. The general result of the occupation of these strong works on the Shaho was to give a false confidence to the Russian Commander-in-Chief. He was, in a measure, justified in the belief that he could hold any force in check. But the works, like permanent fortresses, had their defects. They could be, and were turned. The two army corps that should have been placed more or less in reserve between Mukden and Tieling were not there when they were wanted. Or, if on the spot, they had been so harried and worn out by marches and counter-marches as to be too exhausted to make an effort. These troops had been sent away from the real post of danger, on the west, to assist Liniévitch to the east, in the mountains forty miles away. We have read a good deal in the Russophile press of the gallant stand made by General Liniévitch. But it has failed to report the persistent appeals he made for help to Kouropatkin at a moment when the grand Japanese attack on the Russian right was actually in process of execution. Liniévitch had a fine army of at least 90,000 men, and was

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manœuvring in a hilly country with few avenues of approach, all of which he also had blocked with semi-permanent works. It is true that the Japanese on this flank attacked with a desperation and courage that we have not been accustomed to read of in late years. Hecatombs of dead and dying did not prevent them from renewing their attacks day after day. But 90,000 solid Russian troops, with so much artillery as Liniévitch had at his command, should, one would have thought, have been able to contain both Kawamura and Kuroki under the circumstances. Not so; or at all events Liniévitch did not think so. He has the reputation of being a fire-eater, but even the salamander may have too warm a place. And there can be no doubt that Liniévitch's constant calls for help utterly misled the Commander-in-Chief, and indeed the world, as to the real situation. For days we imagined that the Russian left, and not the right, was in danger of being overwhelmed by the Japanese.

The point to insist on is the danger of relying too much on powerful semi-permanent works and of denuding their neighbourhood of the mobile troops in reserve, who should always be ready to meet the development of a flank attack. It has come to pass that flanks must be turned. Central attacks will always be more or less of a containing kind. It would seem then better in some cases to strengthen the centre rather than the flanks by immobile works, holding the reserves always ready to repel the final efforts that the attacking enemy is certain to make on the extremities of the position. If we take the famous instance of the advance of the Prussian Guards on St. Privat-la-Montagne we see that Canrobert's position was strong enough to repel the first attack. The gallant Marshal called on Bazaine to help him with the Imperial Guard from Plappeville. Before the second attack the Saxons, marching round Roncourt, had cut the whole French army off from its retreat on Verdun. It was the want of the mobile troops that forced the French to retire from the stone walls at St. Privat. Possibly semi-permanent works, if they had been erected, would have delayed for another day the victory of Gravelotte. It is rather the combination of semi-permanent defences and mobile troops that will insure success in battle, than too absolute a confidence in the power of either to fulfil the part that should be assigned to both.

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A REINFORCED CONCRETE CHIMNEY.*

IN the United Shoe Machinery Company's new shops at Beverly, Mass., reinforced concrete has been used in connection with a chimney stack, 141 ft. 1 in. high from the foundations, the construction of which occupied 60 days.

The chimney is 6 feet in diameter inside, and has a foundation 18 ft. square by 3 ft. 6 in. in depth. The concrete in the foundation is composed of one part Portland cement, two parts sand, and four parts stone; and is reinforced with a network of $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. by $\frac{3}{16}$ in. steel T bars placed horizontally. Similar bars worked vertically into the shaft are bent under the horizontal bars.

The shaft is built in two portions, the lower one being 60 ft. high, and consisting of two shells with a 4 in. air-space between them. The inner shell is 4 in. thick and the outer one 6 in. thick; the space between them is connected with the outside atmosphere by small air inlets. In the first 27 feet of the outer shell 72 vertical bars, the same size as those in the foundation, are used, and these are placed in groups; while in the inner shell there are 12 vertical bars, and horizontal rings of 1 in. by 1 in. by $\frac{1}{8}$ in. steel T's are placed in it every 18 in. The outer shell has also similar rings, but in this case they are placed every 3 feet apart.

The next 15 ft. length of the lower shaft has 60 vertical bars, and 12 bars are omitted in every 15 feet after this to the top of the chimney.

At the height of the top of the inner shell the outside diameter of the chimney is reduced, as the air-space is omitted (the inside diameter of the chimney being unaltered), and a moulding is run round the chimney at this point. From here to the top the concrete is 5 in. thick, with the exception of the moulding at the cap. The vertical reinforcing bars in the outer shell are bent slightly at the top of the inner shell, and are continued through the concrete of the upper part of the chimney to the top. Horizontal rings are also placed in the upper part above the moulding, but are spaced 3 feet apart.

In the construction two sets of wooden forms were used, each set being 3 ft. high, and they were made in sections. About 3 ft. of the double part and 6 ft. of the single part were built per day. The concrete used in the shaft was a mixture of one part cement and three parts sand. The foundation is 12 ft. below the ground-level, and its weight is about 161,000 lb., with an additional weight of earth upon it of about 184,600 lb.

The total weight of the chimney is about 234,180 lb., the weight of the steelwork being about 14,440 lb. The stack is guaranteed to withstand a wind pressure of 50 lb. per sq. ft. and a temperature not exceeding 1,500 deg. Fahr. The maximum pressure on the ground is 2 tons per square foot.

* From *Engineering* of 29th September, 1905.

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THE JAEGER COMPANY'S MINIATURE RIFLE RANGE.*

A FULLY occupied warehouse, packed with goods, etc., from top to bottom, in the heart of the City, does not seem to offer much opportunity for a 25-yard rifle range, but the thing has been accomplished, and that without interference to business, without loss of space or of light, and, most remarkable of all, to the entire satisfaction of the London County Councillors, who, very properly, required to be satisfied that the range was absolutely safe before giving their approval.

The necessary dimensions for an efficient miniature rifle range are:— Length, from firing-point to targets, 25 yards. Behind firing-point 15 ft. to 20 ft. for men firing (the prone position occupies 6 ft.), for spectators, rifle racks, accommodation for cleaning, storage of ammunition, etc. Anything less than twenty-five yards diminishes the efficiency of the practice, although, where this length is impossible, twenty yards, or even fifteen, will give good results. Width, 10 ft. at the firing-point, to allow four targets. This may diminish, if necessary, to 8 ft., or less, at the target end, but it is better to keep a uniform width if possible. Where there are a large number of members, the individual cannot get sufficient practice with less than four targets, and is likely to lose interest if the number of targets, and consequently the opportunities of firing, are fewer.

On the warehouse in question a space of the required width and length was found outside, and stretching from west to east over three long skylights above the ground floor. On the left, looking towards the target end, the building rises for several floors; on the right hand is an iron railing, separating the premises from the neighbouring ones, which have a similar range of skylights. The first three windows on the left are protected by revolving metal shutters, to be drawn down after business hours, when the range is used; projecting shields, fixed to the brickwork between the windows at intervals, protect the remaining windows. By means of a simple diagram drawn to scale the shields can be so arranged that a bullet which misses one shield will infallibly be caught by one of the other shields. A similar series of overhead shields prevents an unduly elevated bullet from escaping. On the right a continuous sheet of $\frac{1}{16}$-in. steel plate attached to the railing protects the neighbouring premises.

Behind the target end is a large window, protected, when the range is in use, by folding doors of $\frac{1}{4}$-in. steel plate, with extra metal immediately behind the targets. These doors are closed only when the range is in use. Of the skylights over which the range runs, that nearest to the firing-point is protected by a long revolving metal shutter, and shields similar to those overhead protect the other skylights beneath the range.

* From the *Daily Telegraph* of 22nd August, 1905.

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As these shields are perpendicular, they do not appreciably obstruct the light.

Now that the way has been shown the roofs of buildings can in many cases be employed for the purpose of a miniature rifle range. Sometimes a blank wall of brick can be utilised to form one side of a range, ready-made. An existing parapet wall, if not high enough, and if "ancient lights" do not hinder, can be raised a few feet at comparatively small cost. Where questions of interference with light, or of wind-strains, do not arise a large metal tube, 8 ft. wide and 4 ft. high, forms an absolutely secure range. If the lower side of the tube be raised 3 ft. from the foot-level, men can shoot standing into the tube; while, for the prone position, raised platforms can be fixed. There are several excellent and highly practical devices for conveyance of the targets to and from the firing point, whence they are controlled. The best of these combines a disappearing target, for snap-shooting, with the ordinary stationary targets. It will be found in actual practice that not one bullet in many thousands will touch any shield or point in the range other than the target or immediately around it. At the same time, it is, of course, essential that absolute security at every point be provided for.

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REVIEWS.

TEXT-BOOK OF TOPOGRAPHICAL AND GEOGRAPHICAL SURVEYING.

By MAJOR C. F. CLOSE, C.M.G., R.E.—(Wyman & Sons. Price 3s. 6d.)*

MAJOR CLOSE has at last filled a gap in technical literature which has long wanted filling. For years past there has been a slow but very steady advance in English geographical schools, the tendency of which has been to place England more on a level with her continental neighbours in matters relating to the acquisition of map knowledge of her widespread possessions beyond the seas than was possible under the restrictions which necessarily distinguished Ordnance Survey methods. No standard work on topography, as applied to continents rather than counties, has previously existed in the English language, unless we make an exception of Mr. Wilson's *Topographic Surveying*, which is certainly a valuable summary of the principles of the art from the American point of view. Major Close leaves nothing to the imagination, although he wisely confines himself to the strict limits of his subject, declining to enter into the tempting field of geodetic discussion (on which science there is already an ample literature), and dealing only with those practical issues which bear directly on the final attainment of sound topographical maps. For the first time, too, we have all those branches clearly defined, and the relative value of the map results properly co-ordinated with the object they are meant to serve. The place of topography in the wider field of geography is well maintained; and the principle that it is just as scientific to make approximately accurate mapping (so long as it will always fill its own place in the world's geography without error and without distortion) as to labour through all the preliminaries of geodetic arc measurements, and thus be left hopelessly behindhand in the practical results of useful map-making, is clearly intimated. In short, it is a practical work all through—as a text-book should be—and it is to be earnestly hoped that it will form the basis of topographical instruction in all the geographical schools of England.

So full and so complete is the work in the matter of forms, tables, and illustrations that it would take a long time to refer to all those features of it which deserve special recognition. The illustrations are excellent, and if any criticism can be applied to them it is that they are almost too

* Reprinted by permission from the November, 1905, number of the *Geographical Journal*.

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good. One or two specimens of the very roughest and readiest form of topographical art, as applied by highly trained Indian explorers to districts over which they may have to carry a reconnaissance at the rate of hundreds of square miles per diem, would not have been out of place in a work of this sort.

From the commencement of the book we note that Major Close insists on the importance of a preliminary basis of triangulation, or traverse, for topography, and rightly maintains the advantage of such a basis over any form, or combination of forms, of astronomical observation. His remarks on the preliminary base measurement include a reference to those newer methods which have been introduced by French experts, which render the process of rapid measurement so much more accurate than was formerly possible. It is for this reason, perhaps, that he does not insist forcibly on the necessity for a constant repetition of linear measurements during the extension of the reconnaissance (or "geographical topography"), which was adopted till lately as the best means of compensating error. All the most useful methods of carrying out what we may term irregular triangulation are well explained; but we may, perhaps, note that it has been found in practice *always* necessary to introduce an azimuth value derived from astronomical observation with the computations for interpolating a position by triangulation, whether from three or more points or from two. Whilst Major Close very rightly insists on the uncertainty which attends latitude checks owing to inconstant level deflection, he perhaps depreciates the value of such checks a little too far. The uncertainty must always exist, but in practice it has not been found to invalidate their usefulness to any great extent.

The chapter on the use of subtense instruments for traversing purposes is most useful. It is an essential detail in topographical surveying which is often overlooked. The use of the plane-table is advocated by an expert at the process. One small detail may perhaps be emphasized even further than by the italics which Major Close gives it. *Pins should never be used* to assist the plane-tabler to align his ruler. It is a slovenly expedient which is too often made use of. I have seen a plane-table that looked like a pin-cushion in a military school lately.

The chapter on "Surveys on Active Service" is altogether good. There is a point about map-reproduction in the field which is perhaps worth more discussion. The sun-printing processes (blue prints and the like) can be made use of with far greater facility than either lithography or zincography. The latter may be superior in their results, but the advantage of illustrating the first despatches after an action by a sketch-map made during its progress, and reproduced with the utmost rapidity, are not to be overlooked. It might very well happen that at the close of an extended action covering 8 or 10 miles of front, the position of every brigade could be indicated to the general commanding by means of a series of sketch-maps made during the course of the action, traced and printed within an hour or two, given that light was available. This would hardly be possible by any other means than sun-printing.

On the subject of map projections Major Close is perhaps the best authority in England, and he treats the subject liberally.

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The story of British mapping might possibly be considered as hardly appropriate to a text-book; but the moral of it is far too important to allow of its omission. That moral is best given in Major Close's own words, "No system of sketching, no combination of sketches, and no compilation of previously unconnected material, whether sketches, isolated surveys, or from plans, will result in a trustworthy topographical map." The grand ruling principle of working from the whole to a part, and not *vice versâ*, is the keynote of the whole book—the golden rule which must surely govern all English surveys in the great future before them.

The subject of astronomy as an adjunct to topography is well and fully illustrated. Due value is given to the various methods of determining longitude, and Major Close gives expression to the opinions of all experienced topographical and geographical surveyors in his summary of this subject. It might be expressed as follows: "Never take an observation for an abstract value of longitude if you can obtain that value differentially by telegraph; never use the telegraph if you can get a differential value by triangulation."

Taking it for all in all, it is the best book on topography that has yet appeared in the English language, and will certainly serve as a standard guide for all the many geographical schools in the country.

T. H. HOLDICH.

SPECIAL ARMY SCHOOLS FOR THE EARLY EDUCATION OF OFFICERS.

By COLONEL O. E. RUCK, R.E.

This pamphlet, published by Schultz & Son, Gravesend, is remarkable for its concluding recommendation that boys intended for the Navy or Army should receive their early education in a joint Naval and Military College followed by a course at sea. The author considers that from the age of 11 up to 13 the boy should be educated at an approved and inspected school; then interviewed and nominated to enter the joint college, where he would remain 2 years; he would then join a ship in commission for 2 years; and finally, if found suitable, be admitted into an official Military College. The prospect is an enticing one, as such a system might result in a perpetual good understanding between the two militant forces of the nation. Public opinion, however, has not yet ventured so far; the most that is urged at present is the desirability of amalgamating Woolwich and Sandhurst, and giving all cadets for the officer rank of the Army the same military education together; this is a consummation that is much to be desired in these days, when it is more than ever necessary for all branches of the Army to understand each other and to work in unison.

The author arrives at his conclusion after a consideration of the present system of early education of candidates for the Army. 'For military

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purposes the foundation of character would appear to be the first requisite.' 'The amount of school knowledge absorbed by the average boy can never be very great'; the number of subjects now taught are so many and so diverse that it seems impossible for them to be learned well; it is however 'a time-worn axiom that if a thing is not learnt well more harm is done in the end than good acquired.' 'They do best in the long run who are strong, do not worry themselves about immediate results, and care not over-much as to early success or the reverse.' 'No system of examination at an early age can secure the very best men.'

At the beginning of last year the advisory board on military education made an attempt to postpone the sharp separation during school life between boys destined for the Army and their fellows; and they instituted a 'leaving certificate,' to be granted on the completion of an approved curriculum at a specially inspected school of ascertained merit, this certificate taking the place of a qualifying examination prior to the competitive. 'Thus a premium is placed on the schools considered to be conducted on the best lines for the martial training of boys; the general trend of military educational authorities being in the direction of a higher standard for all, by means of a lever stimulating the educational powers throughout the country to rise to the occasion.' This new procedure was apparently the result of public school authorities, when criticized for their failure to produce better material for the Army, replying that the material had been cut to shape and that the responsibility rested with the military authorities. Before the system of leaving certificates was instituted there already existed three well-known schools working on the desired lines,—the Imperial Service College, Harpenden (formerly the U.S.C., Westward Ho!), the Military College, Richmond, Surrey, and the Army School at Stratford-on-Avon.

It is considered, however, that candidates for the Army can commence their military education at an earlier age than is now the case. Before the days of competitive examination, the system of nominations produced great Admirals, great Generals, and great Indian Administrators. A retroversion towards older methods is now under trial for the Navy, candidates being selected by interview, nomination, a qualifying examination, and further education under the immediate supervision of the Naval authorities. Cannot something on the same lines be attempted for the Army?

A. T. MOORE.

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NOTICES OF MAGAZINES.

BULLETIN OF THE INTERNATIONAL RAILWAY CONGRESS.

September, 1905.

This number consists entirely of reports of the recent meeting of the Congress at Washington, the conclusions arrived at on the various questions, and a summarised account of the discussions at the various meetings. Although one has some doubts as to the representative nature of the discussions, some of the accounts are rather interesting and cast a little light.

THE AUTOMATIC BLOCK SYSTEM.—There now seems no doubt that various quite efficient systems are on the market, and it seems to be established that this is the thing to adopt where no regular Block system has been installed up to the present: but where the traffic is very heavy—and consequently a failure is likely to cause much upset—some provision for manual control is desirable. If there are many stations or level crossings staff is not economised. On the other hand the system protects against other interruptions of the line besides occupation by trains, and with the introduction of corridor trains the same necessity for staff to watch the movement of trains is not felt. The L. & S.W.R. provide telephone arrangements as an auxiliary so that the train men may be able to ascertain the cause of delay if held up by signal.

REINFORCED CONCRETE.—The advantages as a material of Béton Armé seem to be universally admitted. The principal questions raised were as to difficulties in putting in such bridges under lines in operation, both because of time taken for setting and the possible deformation if the load were brought on too soon. It was pointed out that time was saved by this method of construction, as there is no delay in obtaining material such as in the case of bridges which have to be built up in the Shops. Reinforced Concrete is now used extensively in blocks, columns, piles, etc., for railway purposes. The conclusions adopted by the Congress were very favourable.

RAILS FOR HEAVY TRAFFIC.—The discussion was of much interest, but unfortunately space would not admit of giving its whole substance. The principal points brought out were:—(1) The importance of good distribution over the sub-grade of the load. (2) Advantage of enlarging the rail head to save wear on the contact surfaces and so also give better

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bearing for the fishplates, which should be of hard metal. (3) Tests. The temperature during rolling is of much importance. In America, owing to the Steel Trust, great difficulty has been experienced in obtaining rails of a sufficiently high standard. (4) The flanges of Vignoles rails should be not less than $\frac{1}{2}''$ thick at the edges to secure good steel.

C. E. VICKERS.

LA BELGIQUE MILITAIRE.

15th August, 1905.

TRAIN-WRECKING DEVICE.—The following account of a device invented by Colonel Simonis, of the Belgian Engineers, may prove of interest.

The invention consists of an automatic circuit closer. Two of these are placed under the sleepers, at a distance apart slightly less than that of the shortest train that it is desired to wreck. The electrical connections are so arranged that the charges, which are placed in the centre of the line, will only be fired when the two circuit closers are simultaneously depressed. The idea is that, by adopting this system, pilot engines or short pilot trains will fail to explode the charges. The apparatus being placed under the sleepers, it is very difficult to detect its presence. It appears that the invention was on view at the Liège Exhibition.

A. J. CRAVEN.

NATURE.

September and October, 1905.

ENGINEERING (*p.* 465).—The opening address, in this section of the British Association meeting at Cape Town, was given by Colonel Sir C. Scott-Moncrieff, R.E. It touched chiefly on the science of irrigation, which has a special interest for South Africa, and on which the best years of his life in India, Southern Europe, Central Asia, and Egypt had been spent.

Pumps and windmills, artesian wells, well irrigation, canal irrigation, and water storage were illustrated by examples of works carried out in various countries. The necessity of drainage being attended to, when designing irrigation works, was pointed out. For a long time no attention was paid to drainage. It was taken for granted that the water would be absorbed or evaporated, and get away somehow without doing any harm. This may hold good for high-lying lands, but alongside of these are low-lying lands, into which the irrigation from above will percolate and produce water-logging and marsh.

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In entering on any large project for irrigation it should be considered what will be the effect of pouring water on the soil, for it is not always an unmixed benefit. A dry climate may be changed into a moist, and fever and ague may follow. Brackish water is harmful. In all cases it is important to establish by law the principle that all rivers and streams above a certain size are national property, to be utilised for the good of the nation, and it is advisable that Government should take the initiative in laying out and constructing the canals and secondary channels.

The various modes of distributing and assessing water in Italy, America, India, and Egypt were explained and discussed.

DUST FROM AUTOMOBILES (*p.* 485).—A great deal of bad feeling has arisen against the motorist on account of the dust which he produces, and it has become imperative to see what can be done to minimise this nuisance.

Special treatment of the roads is too expensive to be carried out on a large scale; it is therefore important to modify the designs of cars so that the dust raised may be reduced to a minimum, and also to find some simple means of checking the dust of cars already in use. One of the simplest defects to remedy is the direction of the exhaust, which is sometimes pointed downwards, thereby causing much dust, and an improvement may be made very simply. The exhaust, if suitably directed, may be used to *lay* the dust caused by the passage of the car, by discharging it from a horizontal pipe, taken across the back of the car, having a line of holes along its length. A number of photographs are given showing the dust-raising qualities of various cars, run at a uniform pace on the Crystal Palace cycle track, kept covered with flour of a definite thickness. It was seen that it is possible to make cars comparatively dustless, though the means of doing so are not, as yet, well understood. It was however clearly shown that tool boxes, which are often carried low down behind a car, have a bad effect. Mud-guards, if they come low down, are bad, and it is desirable that the car should slope upwards towards the back.

THE ELECTRIC MICROMETER (*p.* 495).—As knowledge increases it becomes more minutely exact, and the physicist has often to measure lengths much less than anything visible in the microscope. The smallest measurements made with this new instrument due to Dr. Shaw were in connection with the movements of a telephone diaphragm, viz., 1/2,000,000 *m.m.* It is twenty times more sensitive than the interferometer, with which, by using interference bands of light, we can perceive movements of 1/100,000 m.m. In problems on the constitution and molecular properties of matter, there are obvious possibilities before this apparatus, for by it we can bring two surfaces of any hard metal to molecular distance (or less) from one another, and keep them there while any desired physical change is produced in the surfaces, or in the medium surrounding them.

The mode of using the interferometer above alluded to is well explained by Dr. Tutton in the *Times* of 18th October. The instrument

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has been used in the determinations of the expansion of gas thermometer porcelain, as well as that of many crystallised substances which cannot be adequately polished.

PHYSIOLOGY.—By Dr. Bruce (*p.* 496).—His address to the British Association at Cape Town is most interesting. It shows how very rich South Africa is in animal diseases, every species of domestic animal having one or more specially adapted for its destruction.

THE FAYUM (*p.* 535) is a circular depression in the Libyan desert, having an area of more than 3,000 square miles. It is situated to the west of the Nile some distance south of Cairo. The lowest part of the district is occupied by the Lake Birket-el-Qurun, which has an area of about 85 square miles; but this area is continually diminishing by evaporation. In historical times, as is well known, a large part of the Fayum was occupied by the Lake Moeris. By successive reclamations of the alluvial lands this lake has been reduced to less than one-eighth of its original area, represented now by the Birket-el-Qurun. Until the year 1898, when the examination was commenced by the Geological Survey of Egypt, little was known concerning the geology of this district, but now the palæontological treasures yielded by the Fayum have made that province famous among geologists and zoologists; the outcrop of strata was crossed, upon which a considerable number of mammalian and reptilian remains lay exposed, many in an excellent state of preservation. It is probable that these remains were brought down from the African interior by a great stream which flowed in a north-westerly direction, passing through the ancient lake occupying the site of the Baharia Oasis. At that period the shore-line would be near the Fayum, and the Nile would flow into the sea near the same point.

W. E. WARRAND.

REVUE D'HISTOIRE.

October, 1905.

STUDIES ON INFANTRY TACTICS IN THE 18TH CENTURY.—Extracts are given from a forthcoming work on this subject, shewing how the "deep order" was started by Folard, was supported by Saxe, and was elaborated by Mesnil Durand.

THE CAMPAIGN OF 1793.—*Army of the North and the Ardennes.*—A history of this campaign, from Valenciennes to Hondtschoote, is about to be published. Parts of it have already appeared in the *Revue*, and the last chapter, describing the battle of Hondtschoote, is now given. The blunders of the British Government in insisting on the siege of Dunkirk, and making inadequate provision for it, enabled the French to bring 45,000 men against the covering army of 16,000. But owing to the inexperience of Houchard and his staff only half the French forces took

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part in the battle, and the sole result of it was the raising of the siege. If the French had been better handled the siege corps under the Duke of York might well have been cut off.

THE WAR OF 1870–1871.—*The Army of Chalons.*—By August 25th, Macmahon's army was on the Aisne above Rethel. The German head-quarters were at Bar-le-Duc, 60 miles to the south-east. Moltke was unwilling to check the advance of the German armies towards Paris, but reports from various quarters that the army of Chalons was going to the relief of Metz made him prepare for a wheel northward. He worked out a plan for the concentration of 150,000 men by the 28th at Damvillers, south of Montmédy, in case of need. The evidence he had to go upon, and the arrangements he made, afford a most interesting example of applied strategy.

E. M. LLOYD.

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CORRESPONDENCE.

THE PREVENTION OF DAMPNESS DUE TO CONDENSATION IN MAGAZINES.

DEAR SIR,

The Transcript in the September number of the *R.E. Journal* is accurately described by Colonel Seddon as interesting, but at the same time it cannot be said to detail any novel principles.

The broad principle, that air will always absorb moisture up to its point of saturation and will raise to its own temperature that of any objects over which it is passed, has been successfully applied in the construction of our own magazines for many years.

It would in fact seem that we have taken a short step further than the American Engineers, in that in our own service the rules as to the opening and closing of ventilators according to the conditions of weather, which used to be more or less perfunctorily followed by the District Gunner, have now practically been discarded in favour of an automatic system.

In the roof of each chamber is an extract shaft leading to an external wind-revolved cowl, which draws the air with sufficient rapidity through the building. Free inlets are also provided, ventilating bricks in the external walls, and, whenever practicable, open iron-barred gates instead of closed doors at the external entrances of the passages. The brick linings to the walls and ceilings form a further safeguard against dampness, as in wet weather they absorb moisture from the air, subsequently parting from it as conditions become more normal.

Thus in a properly designed magazine a continuous current of air is provided at all times, and even in damp, foggy weather the deposit of moisture is so slight as to be practicably inappreciable.

Yours truly,

H. J. WALKER,

Capt., R.E.

The Editor, "R.E. Journal."

PRECAUTIONS AGAINST FEVERS.

DEAR SIR,

In the admirable article, by Colonel Harrold Fenn, C.I.E., R.A.M.C., in the October number, *R.E. Journal*, on the above subject, there is no mention of a very simple and efficacious preventative of malaria which is not nearly so well known as it deserves to be. It is the essential oil of

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the white birch tree, or, what is very nearly as good and more easily obtainable, oil of tar.

The fever mosquito is only dangerous at dusk, and the part usually attacked is the instep. The oil has about the appearance and thickness of stout, but it can be obtained colourless without any difference in its strong tarry odour. If the finger be damped with it and rubbed on exposed parts, no mosquitos or midges will come near for about six hours.

Many others of the essential oils have the same effect, but none, so far as the writer has tried, lasts so long.

This simple preventative has been tested in Norway, Canada, Mauritius, and India by the writer and his family, always with success. By using it he has passed many weeks in some of the most malarial parts of India and Burmah without ill effect.

The oil can be obtained at the A. & N. Stores or any of the principal London chemists.

Yours truly,

H. DE H. HAIG,

Colonel.

The Editor, "R.E. Journal."

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RECENT PUBLICATIONS.

The War in the Far East, by the Military Correspondent of *The Times*. (9½ × 6. Murray).

The Siege of Port Arthur: Records of an Eye-Witness, by D. H. James, Special Correspondent of the *Daily Telegraph*. (8½ × 5½. 10s. 6d. Unwin).

Die Schlacht bei Mukden. Mit 8 kartenbeilagen. (Beiheft zum Militär-Wochenblatt). (Pamphlet. Mittler & Sohn, Berlin).

Die Schlachtfeldbefestigung nach den Erfahrungen des Russich-Japanischen Krieges den einschlägigen Veroffentlichungen, Reglements und der Kriegsgeschichte, von Hauptman des Geniestabes J. R. Malczewski v. Tarnalva. Mit 68 skizzen und 8 tafeln. (Pamphlet. Siedel & Sohn, Vienna).

Report on the Surgical Cases noted in the South African War, 1899–1902, edited by Surg.-General W. F. Stevenson, C.B., K.H.S., A.M.S. (Folio. 7s. 6d. Wyman & Sons).

Im Kampfe gegen die Herero, von Oberleut. E. v. Salzmann. (4to. Berlin).

Sea Power in its Relations to the War of 1812, by Capt. A. T. Mahan, U.S. Navy. 2 vols. (9 × 6. 36s. Sampson Low, Marston).

Manual of Military Ballooning. Part I. Official. (7½ × 5. 1s. Wyman & Sons).

Unterricht für die Ballonabteilungen. Official. (Vienna).

Gustav Adolph, King of Sweden: The Father of Modern War, by Lieut.-Colonel Hon. E. Noel. (8vo. London).

The Dickson Manuscripts. Diaries, letters, etc., of the late Major-General Sir Alexander Dickson, G.C.B., R.A. Series C. 1809–1818, edited by Major J. H. Leslie, late R.A. (9½ × 6. 2s. 6d. R.A. Institution).

The Fighting Man of Japan: The Training and Exercises of the Samurai, by F. J. Norman. (8½ × 5½. 2s. 6d. Constable).

Histoire et Organisation Militaires des Chemins de Fer, von Dr. Joesten. Traduit de l'allemand par le Lieut.-Colonel B ° ° °. (8vo. Paris).

Principles of Electric Power (Continuous Current), by A. H. Bate. (4s. 6d. Spon).

Elementary Electrical Engineering in Theory and Practice, by J. H. Alexander. (8vo. 3s. 6d. Crosby, Lockwood).

Motor Vehicles for Business Purposes, by A. J. Wallis-Taylar. (8vo. 9s. Crosby, Lockwood).

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Portland Cement: Its Manufacture, Testing, and Use, by D. B. Butler. (16s. Spon).

Sewerage and Sewage Disposal, by Prof. Henry Robinson. (7s. 6d. Biggs & Co.).

The Law and Practice relating to Patents, Trade Marks, and Designs, by David Fulton. (12s. 6d. Jordan & Sons).

Radio-Activity, by E. Rutherford, D.Sc. F.R.S. ($8\frac{1}{2} \times 5\frac{1}{2}$. 12s. 6d. Cambridge University Press).

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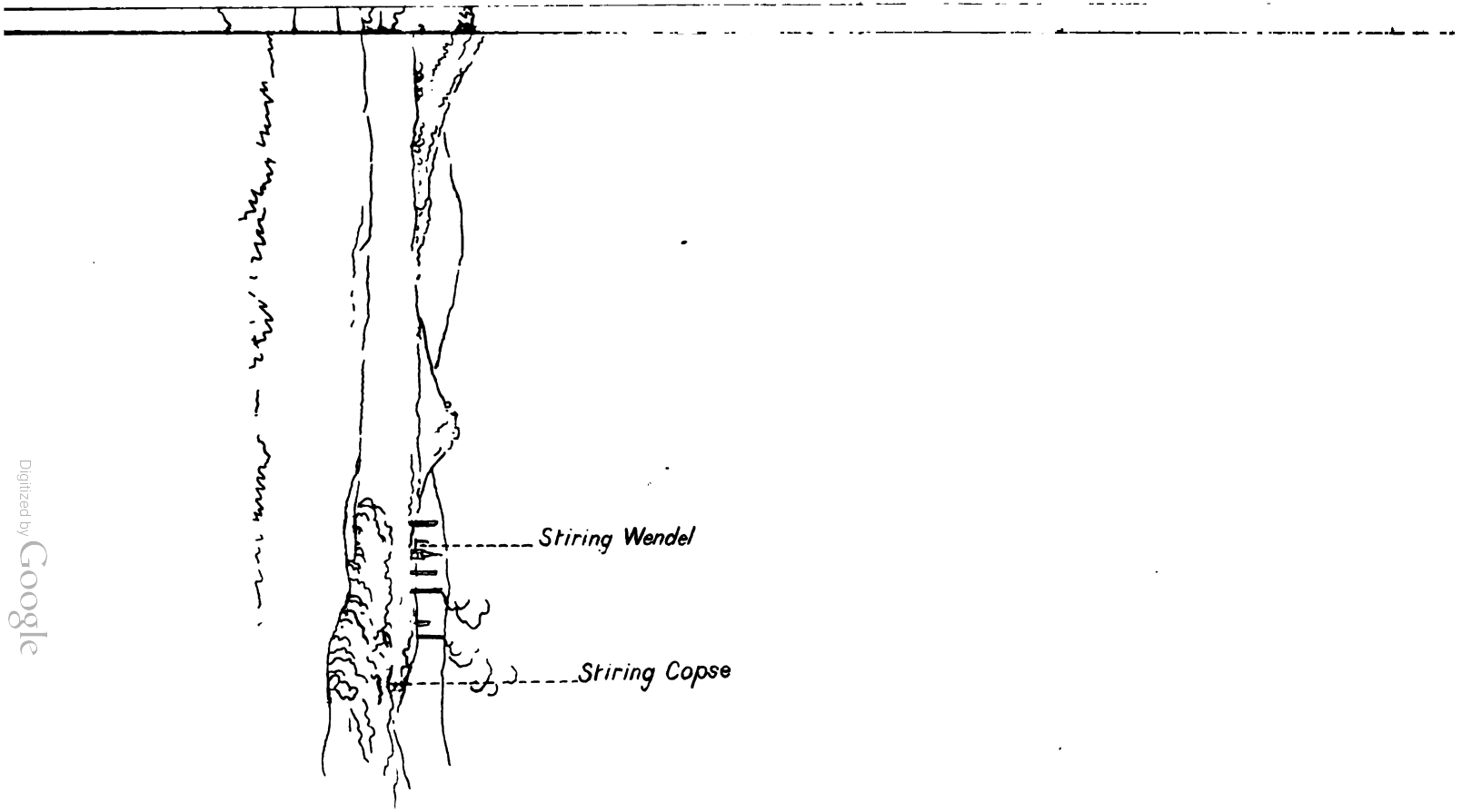

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